American Species of the Genus Sceliphron Klug

The Spruce Gall Louse

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AMERICAN SPECIES OF THE GENUS SCELIPHRON KLUG

THE SPRUCE GALL LOUSE

(*Chermes abietis* L.)

The Host of *Ablerus clisiocampae* Ashmead

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This thesis consists of two separate papers and a short note which was published as a result of observations made during the writer's graduate course, all of which are here presented together for the degree of Doctor of Philosophy.

The first paper is a systematic treatment of the American species of the genus Sceliphron Klug. The first part of the paper is devoted to a detailed study of the external anatomy and male genitalia, followed by tables showing the position of this genus in the superfamily Sphecoidea. This in turn is followed by a key to the American species included in the genus, and redescriptions of the different species.

The second paper deals with the spruce gall louse (Chermes abietis L.), a common pest of the Norway and white spruces--paying particular attention to the methods of control. The first part of the paper is drawn to some extent from other sources for the purpose of presenting a well-rounded account of this insect. Since all control measures must be based on an intimate knowledge of the life history and habits of the insect to be controlled, a detailed study of the life history and habits of this insect was made, and is here presented. Following this is a detailed account of experiments with a number of insecticides. Based on these experiments are a number of recommendations, which, if carefully followed, should result in almost complete control of the pest.

The note included was published in corroboration of a similar observation independently made but previously published by another worker, and adds evidence to that already published in regard to

the host habit of the Chalcid parasite Ablerus clisiocampae Ashmead. This insect is here conclusively proved to be at times at least an egg parasite of the tent caterpillar, contrary to the known host habits of all other members of the group to which the parasite belongs.

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Introduction.

This paper deals with the American species of the genus Sceliphron which is one of the genera of the Sphecidae, or digger wasps.

The writer wishes to express his gratitude to Dr. H. T. Fernald for his untiring interest in the work, which was materially evidenced by the large amount of material obtained from many museums and private collections for which he assumed the responsibility; and without which the writer's task would have been many times more difficult, if not impossible. Besides being supplied with a large amount of material upon which to work, the writer was given the use of a number of papers in the private library of Dr. Fernald, including notes on specimens of this genus in European collections, taken by him on a recent trip to Europe. To Dr. Guy C. Crampton, the writer is grateful for helpful suggestions concerning external anatomy. Thanks are here extended to Dr. C. W. Hewitt and F. W. L. Sladen for the examination of one of Provancher's types at Quebec. The list of museums, colleges, and private individuals who have kindly loaned material for this work is a long one; to all of them the writer's thanks are extended.

General Characters

Digger wasps of the genus Sceliphron are of quite good size, ranging from one-half an inch to an inch or more in length. Great variation in size is found among the members of the same species. The colors are mainly black and yellow. The black may vary from fuscous to a jet black*. The relative amount of black and yellow present vary greatly even in the same species; in general, specimens taken in southern regions have more yellow than those taken farther north.

A noticeable feature in this genus is the elongate, thread-like petiole. This is continuous, not consisting of two segments as in many of the Sphecinae.

These wasps are quite hairy in many parts of the body. When the hairs are extremely minute and procumbent, giving the surface a silky appearance, the condition is spoken of as "sericeous." When they are coarser but still procumbent, forming a dense mat over the surface, the condition is termed "densely pubescent". This condition is found on the clypeus and the lower part of the face. When they are coarser, longer, upright, and separate from one another, I have used the term "Hairy," or "coarsely hairy." The head and thorax of the genus Sceliphron are more or less hairy. Almost all

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* The yellow varies from a pale yellow to ferruginous. The action of cyanide may be responsible for the ferruginous color in some cases; wherever such seemed to be the case, the color has been considered yellow in this paper.

the surface of the body is at least "slightly sericeous."

Most of the surface of the head and thorax, when not obscured by the presence of too much hair, will be found to be more or less punctate. In some cases the punctation will consist of mere slight depressions of the surface; in other cases quite deep pits will be found. Close examination shows that many of the hairs arise from these pits. The surface of the abdomen and of the legs is mostly non-punctate.

Many parts of the surface of the thorax are covered with more or less parallel lines, the depressions between these lines being usually pitted. This condition is known as "striate."

The wings are fairly large, and are nearly hyaline, having a tinge of color varying from ferruginous to fuscous. They are usually clouded with fuscous near the apex. The color of the viens varies from ferruginous to fuscous.

External Anatomy

Head

The hypognathous head, viewed from above, seems to be two to three times as wide as long. In that position, the compound eyes take up a little over one-half of the width of the head. In the area between them we find the three ocelli, arranged in the form of a nearly equilateral triangle, the two posterior ocelli being at about the highest part of the head. The distance between them is a little less than that from these ocelli to the margins of the compound eyes. Viewed from the front, the head appears almost quadrate. The face is somewhat depressed, and in its centre is an elevation on which the antennae are inserted. The compound eyes extend downward almost to the bases of the mandibles, and nearly touch the outer margins of the clypeus. The clypeus is somewhat variable in shape but with one or two exceptions is bidentate at the lower margin. In the female this condition is represented by two more or less rounded lobes. In males of fasciatum the lobes are extremely shallow, making the lower margin almost straight across. In males of figulum the teeth are often very elongate and narrow, and are quite widely separated. In all males, except those of fasciatum the teeth are more pointed than those of the female. The clypeus is rather definitely marked off from the rest of the head, the line of demarcation being just below the insertion of the antennae. The antennae consist of twelve segments in

the female, and of thirteen in the male. The typical antenna is composed of three parts--the scape, pedicel, and filament. The scape, or basal segment, is composed of the scape proper, and the bulb, which articulates in the socket in which the antenna is inserted. The scape is cut off obliquely at the base, and on its inner surface is attached the bulb, which, while appearing like a separate segment, is generally considered a part of the scape. The scape is the most robust of the antennal segments. The pedicel is small, about as wide as long, and about half the width of the scape. The first is the longest of the filament segments, their length gradually decreasing towards the end. The filament reaches its greatest thickness at about the third segment, gradually narrowing towards the tip. The antennae are frequently sericeous--i. e., covered with microscopic procumbent hairs, giving the surface a silky appearance. The antennae are usually carried in a curled position.

The mouth parts are for biting and chewing. The mandibles of the female are large, grooved and ridged, shining, and usually have a tooth on the inner surface near the apex, while those of the male are less robust, and not toothed.

That part of the face above the clypeus is known as the frons, and this extends upwards to the top of the head, which is known as the vertex. Since the vertex is not marked off from the frons by any line or suture, its limits are rather indefinite. The frons is also extended downward on each side of the clypeus to meet the narrow strip of the genae

above the bases of the mandibles. In the lower middle portion of the frons is the slight elevation in which the antennae are inserted. Extending from the insertion of the antennae to the median ocellus and then posteriorly between the lateral ocelli and then posteriorly between the lateral ocelli is an indistinct suture known as the frontal suture.

Behind and below the compound eyes are the genae or cheeks, the part below the eyes being very narrow. Behind the genae and the vertex is the occiput, which surrounds the neck, or anterior portion of the prothorax.

In the centre of the occipital region is a definitely margined depression in which the neck articulates.

The head, with the exception of the eyes, is more or less hairy. The clypeus and most of the rest of the face are densely clothed with a mass of procumbent, short hairs, sometimes with additional upright ones. The remainder of the head is sparsely clothed with upright hairs. The surface is more or less punctate.

Prothorax.

The prothorax is smaller than either the meso- or metathorax. It consists of two parts--the short, narrow neck, and the main portion of the prothorax into which the neck broadens out posteriorly. The true sternum has become reduced to a small triangular plate between the coxae. The pleura have extended on to the ventral surface until they meet along the median ventral line, thus replacing the sternum to some extent. The notum, or dorsal plate has extended downwards on

the sides and posteriorly to a point behind the coxae. Extending backwards from the middle of the side of the prothorax is the prothoracic lobe, which is more or less rounded in shape. This never extends back as far as the tegulae. In front of the prothoracic lobe is a depressed area, which may be somewhat triangular in shape. On the ventral side, the neck seems to be separated from the main portion of the prothorax, or collar, by definite sutures, giving the former the appearance of a wedge pointing backwards into the collar. Between the pronotum and mesonotum is quite a deep furrow, the pronotum here not being closely appressed to the mesothorax. In the middle of the pronotum is a longitudinal median depression. The surface of the prothorax is nearly smooth, being only weakly punctate; never striate. It is more or less covered with sparse, coarse, hairs.

Mesothorax. The principal plate of the dorsal surface is called the mesonotum. This term is incorrectly applied, since the term notum should mean the whole dorsal surface of any thoracic segment, but since the term mesonotum has been used by most workers to designate this plate, it will be so used throughout this paper. The posterior margin of the mesonotum is just behind the fore wings; it extends laterally to the tegulae, anteriorly to the pronotum, downwards to the prothoracic lobes, and its margins next to the tegulae are somewhat reflexed. In the middle of the anterior portion of the mesonotum is a well-defined line, which may extend backwards half the length of

the plate, which is minutely and densely punctate, often finely striate, and covered with scattered long hairs. Behind the mesonotum is the scutellum, which is a transverse plate. It is often more or less striate, the striations being longitudinal. Behind the scutellum is the so-called post-scutellum. Covering the bases of the fore wings are the tegulae, which are semi-circular, saucer-shaped plates.

The pleuron and sternum of the mesothorax are completely fused together, no division between the two being visible. The mesopleuron is bounded posteriorly and above by a groove, which begins in a swelling above the coxa, and runs obliquely forward and upward to a point below and behind the fore wings. While this is in about the location of the pleural suture of the typical thoracic segment, it cannot be considered such in this case, since the area posterior to it is metathoracic. Near the front of the mesopleural region is a suture cutting off a narrow strip from the main part of the mesopleuron. This is called the episternal groove, and the two parts of the mesopleuron thus marked off, the episternum and epimeron. These last two terms are incorrectly applied, since the epimeron has been defined as "the principal pleural plate lying behind or above the pleural suture, in general forming the posterior half of the pleurum," and "pleural suture" has been defined as "the external suture between the episternum and epimeron, extending from the wing process to the coxal process." Since the episternal groove cannot be considered

homologous with the pleural suture, it can readily be seen that the terms epimeron and episternum are incorrectly applied, but the usual practise has been followed in this paper. The episternal groove extends across the sternal region also. The middle of the anterior part of the episternum is hollowed out to receive the prothoracic lobe. The upper parts of the episternum and the epimeron are cut off by sutures. The mesopleuron is coarsely punctate, sometimes striate.

Metathorax. The metathorax is so fused with the true first abdominal segment, propodoeum, or median segment, that its limits cannot in all cases be exactly determined. It is distinctly marked off from the mesothorax except just above the metacoxa, where there is a swelling for the purpose of preventing too much upward bending of the coxa. The dorsal surface of the metathorax is represented by the so-called post-scutellum. The propriety of terming this plate the post-scutellum is open to question, but since it is the term used by systematists, it will be so used here. It is a narrow, transverse plate, less than half the width of the scutellum; enlarged at the sides and somewhat produced forward to the wings. The centre of this lateral enlargement is very much depressed, the edges being ridged and the wing articulates in the hollow between the two ridges. The metapleural region is very elongate, extending from the base of the hind wing to the metacoxa, a distance considerably more than half the length of the thorax. The anterior and upper part is somewhat wedge-shaped, coming down to a point in a pit just above

the mesocoxa, where it is joined by the horizontal portion of the metapleuron, which extends back to the hind coxa. This is sometimes definitely marked off from the lateral region of the median segment by a deep groove, or the division may be quite indefinite. As is the case with the mesothorax, the metapleuron is completely fused with the sternal region. Its anterior, wedge-shaped portion is usually smooth and almost devoid of pubescence. At about the mid-point of the posterior margin of this wedge is a pit.

Abdomen. The true first segment of the abdomen, which has been superimposed upon the metathorax, is called the median segment, or propodeum. The second true abdominal segment is divided into two parts--a long, slender petiole--and its dilated portion, which forms the so-called first dorsal abdominal segment. This first dorsal segment together with the petiole will be referred to as the first abdominal segment. The main portion of the abdomen is composed of six segments in the female and of seven dorsal and eight ventral segments in the male.

The median segment is divided into four regions--a dorsum, or central portion, two sides, and a posterior end, these last three areasbeing continuous with each other and surrounding the dorsum on three sides. The dorsum is more or less squarely cut off in front by the post-scutellum, and is surrounded and marked off by a broad shallow furrow,

and in the middle is a shallow longitudinal depression. About one-fourth of the way back in the pleural region of the median segment is a spiracle, situated just below the lateral depression. The median segment is always more or less striate; in fistularis it becomes quite coarsely so, while in other species studied it is minutely striate. The striations run obliquely up the sides of the median segment and transversely across the dorsum.

The petiole is elongate, straight, slender and subcylindrical, smooth, shining, not punctate, almost without hairs or pubescence, although it may be faintly sericeous; and is about equal in length to the whole thorax. It articulates with the median segment just above the hind coxae, and is held in place and moved by means of a prominent curved dorsal muscle known as the funiculus. The ventral part of the petiole broadens out distally to meet the sternum of the second abdominal segment. Above the distal end of the petiole is a convex plate, which constitutes the first segment of the main body of the abdomen. The sides of this plate are extended downward as two flaps, one on each side of the petiole, and extend below the sternum.

The main portion of the abdomen is somewhat ovate, and is more or less pointed at the tip in the female, the sting often being protruded. The second segment is the largest in every way. Spiracles are present on all segments, but are visible on only two, three, or four, depending upon the amount of telescoping which has taken place. The spiracle of the first segment is very near to the front, about half way from the

attachment of the petiole to the highest point of the segment. The others are situated in about the middle of the anterior part of each segment. The hypopygium, or last ventral segment in the female is long, triangular, pointed and strongly convex. It usually extends beyond the last dorsal segment. The abdomen of the male is comparatively shorter and less pointed at the end. There are seven visible dorsal segments, and eight ventral. The hypopygium is shorter, somewhat truncate at its end and is partially concealed by the seventh ventral segment which is partly telescoped over it. Most of the abdomen is smooth, non-punctate, and no more than slightly sericeous. The female hypopygium is punctate, and the last segment or two have numerous long hairs. The posterior margins of the ventral abdominal segments are very shallowly emarginate.

Legs. The legs are long, the fore legs being the shortest, and the hind ones the longest and most robust. They are more or less sericeous throughout and in addition, the coxae are usually sparsely clothed with long hairs. The coxae are subconical, larger proximally, and the bases of each pair are in close proximity to each other. The trochanters are subconical, larger distally, smaller than their respective coxae, and may have a few scattered long hairs. The femora are without spines but with a very few scattered long hairs. The fore and middle femora are longer than their respective tibiae, while the hind femora are a little shorter than their tibiae.

The fore femora are somewhat curved, while the others are nearly straight. All are larger in the middle than at their ends and all have a slight constriction at the base, suggesting another segment which may possibly correspond to the second segment of the double trochanter of the terebrantiate Hymenoptera. The tibiae are all narrow at the base and broaden out to the apex. They are densely sericeous, sometimes almost pubescent. They have a few small spines scattered over their surface in addition to those at the apex, where we find several small spines, together with one or two large ones. At the apex of the fore tibia we find a long, stout, curved, and modified spine with a chitinous blade which bears a row of closely set fine hairs on the surface next the metatarsus. This with a corresponding modification in the metatarsus constitutes a cleaning apparatus. The middle tibia bears two long, stout, simple spines of unequal length. The hind tibia bears two spines, one of which is simple, while the other is larger, and modified in a manner similar to that on the fore tibia, but without being much curved. The tarsus consists of five segments. The first, or metatarsus, is the longest; the next three are consecutively shorter and the fifth segment is nearly as large as the second. The segments are narrow at the base and broaden out on both sides to the apex, each segment being joined to the middle of the apex of the pre-

ceding one. All are thickly covered with spines on the under side, with two or more larger spines on each side of the apex of each. The last tarsal segment bears at its apex two claws between which is found the pulvillus. The claws are long, smooth, and pointed, and may bear on the innter surface a minute tooth. Arising from the inner base of the claw, and extending across to its tip is a long spine-like bristle. The hind coxae are placed at the extreme posterior end of the metathorax, and the legs are pointed backwards.

Wings. The wings are hyaline with a ferruginous to fuscous tinge, and are usually clouded at their ends. The venation is quite uniform throughout the group, and presents no characters of value in determining species. The distinguishing feature of the venation of the wings in this group is the fact that the second cubital cell receives both recurrent nervures. This is also characteristic of the sphecinae and some Podiinae, but not of the Chlorioninae. In the hind wings the cubitus is approximately interstitial with the transverse median nervure. Since the wing venation presents no features of value in determining species, a detailed description of it will not be given. The wings, with the parts named after Cresson are shown in Plate II, figs. 6 and 7.

Male Genitalia

The structure of the male genitalia throws quite a little light on the relationships of the various species. The parts of the typical genitalia are as follows:

(1) Cardo, or basal segment
(2) Claspers
(3) Uncus, or central portion
(4) Volsellae
(5) Sagittae

The claspers are the two larger outside pieces, which usually enclose the other parts to some extent. They are termed by Radoskowski the branche du forceps. The uncus is the central piece of the genitalia. This may be a single undivided piece, but in many genera it is divided into two hook-like parts more or less united to each other. Possibly it is this condition which led Radoskowski to call this structure the "hooks" ("crotchets"). Next to the uncus we find the sagittae, and outside of them and next to the claspers, the volsellae. In many cases the sagittae and volsellae are more or less fused together, in which case Radoskowski terms the whole structure the "bouclier."

In the genus Sceliphron we find the following features:

The cardo is a small plate, closely applied to the claspers, which are cut off obliquely at the base.

The claspers are long and stout, and almost entirely enclose the other parts from above. There are a few scattered hairs at its extremity. At the bases of the claspers are two inward projections which meet.

Just ventral to the claspers we find the uncus, or central structure of the genitalia. This seems to consist of two pieces, loosely connected by a membrane three-fourths of their length. They originate near the base of the claspers, and have narrow extensions into the basal region. The outer portions, which are not connected by a membrane, are more heavily chitinized, and are more or less curved or hook-shaped. On the ventral side, at about the place where the hooks separate are two lobes, bordered with short spines. Since these hang directly downward, they may be pushed to one side or to the other when the genitalia are mounted for study.

Ventral to the uncus and connected with the anterior ventral edge of the cardo is the combined structure composed of the volsellae, and the sagittae, which Radoskowski calls the "bouclier". This is composed of the volsellae, and the pieces which I will term sagittae, fused to the inner side of the volsellae. Whether they are homologous to true sagittae may be open to question, but they will be termed such in this paper.

Ventral to the genitalia is the 8th ventral segment of the abdomen, called the hypopygium (couvercle genitale of Radoskowski). This is a sub-triangular plate which conceals part of the genitalia.

These structures have proved useful in determining specific relationships. The genitalia of the different

"varieties" and species which I have placed under caementarium present no essential differences, showing that the whole series constitutes but a single species. The genitalia of fistularis and fasciatum are very different from any of the others, showing these species to be distinct. Those of lucae and figulum are very similar to those of caementarium, but these species are very evidently distinct from the latter, because of structural and other differences.

Classification and Analytical Keys.

A key to the families of the Sphecoidea is given by Dr. Ashmead (Can. Ent. Vol. XXXI, p. 152.) and will not be repeated here. The following key to the sub-families is taken from that prepared by Fernald (Digger Wasps of North America. Proc. U. S. Nat. Mus., XXXI, p. 308) and from Ashmead (Can. Ent. Vol. XXXI, p. 348).

Analytical Key to Subfamilies of Sphecidae

1. Second cubital cell receiving only the first recurrent vein; the second recurrent vein received by the third cubital cell, or at least beyond the second transverse cubital. (Both recurrent veins are received by the first cubital cell in a few extra-limital forms)----------2

Second cubital cell receiving both recurrent veins, or the second recurrent vein is interstitial with the second tranverse cubitus, although sometimes the first recurrent is interstitial with the

first transverse cubitus, or then received by the first cubital cell----------3

2. Antennae inserted on the middle of the face; claws with one to six teeth beneath; tibiae strongly spinous, or at least never with weak or feeble spines; tarsal comb in female present (except in Isodontia) ----------Chlorioninae (Sphecinae Authors)

Antennae inserted far anterior to the middle of the face; claws simple, without teeth, or at most with a single small tooth near the middle; tibiae smooth, not spinous; tarsal comb in female never present----------Podiinae.

3. Claws simple, without a tooth beneath; tibiae more or less spinous; tarsal comb in female present; abdomen most frequently very elongate, the petiole composed of two segments, rarely of only one segment; cubital vein of hind wings usually originating beyond the transverse median vein----------Sphecinae (Ammophilinae Authors)

Claws simple, with a single tooth beneath, although sometimes very minute more rarely without a tooth; tarsal comb in female absent; abdomen always with a one-segmented petiole; cubital vein of hind wings interstitial or nearly so----------4.

4. Antennae inserted on the middle of the face; metathorax with a large U-shaped area above; mesopleura not longer than the height of the thorax----------
----------Sceliphroninae

Antennae inserted far anterior to the middle of the face, on or just above an imaginary line drawn from the base of the eyes; metathorax without a large U-shaped area above; mesopleura much longer than the height of the thorax----------Podiinae.

Key to Genera of the Sceliphroninae

Species black and yellow, not metallic; clypeus flat, at apex usually bidentate; transverse median nervure in front wings not interstitial with the basal nervure, but uniting with the median vein a little before the origin of the basal nervure; petiole of abdomen about twice as long as the median segment----------Sceliphron Klug.

Species metallic blue or violaceous; clypeus anteriorly tri-dentate; transverse median nervure in front wings interstitial with the basal nervure; petiole of abdomen not or scarcely longer than the median segment----------
----------Chalybion Dahlb.

Key to American Species of Sceliphron

1. Tegulae and scape of antenna black-------fasciatum Lep.
   Tegulae and scape of antenna yellow----------2
2. Abdominal segments bordered with yellow----------3
   Abdominal segments (except first) entirely black----4
3. Yellow border of abdominal segments wide---lucae Sauss.
   Yellow border of abdominal segments narrow----------
   ----------jamaicensis Fab.

4. Median segment definitely marked off below from metathorax by a deep groove----------fistulare Dahlb.

Median segment not definitely marked off below from metathorax----------5

5. Hind legs with the basal portion of the tibiae and the greater portion of the tarsi yellow---------

----------caementarium Drury

Hind legs almost entirely black----------

----------figulum Dahlb.

Genus Sceliphron Klug

Sceliphron Klug, Neue. Schrift. Ges. naturf. Fr. Berlin III, 1801, p. 561.

Pelopoeus Latreille, Hist. nat. Crust. & Insect. III, 1802, p. 334. Genotype Sceliphron spirifex (Linné), designated by Bingham (Faun. Brit. India, Hym. I, 235, 1897.

The genus Sceliphron was established by Klug in 1801, including under it the following species: spirifex (Sphex spirifex Linné); madraspatanum (Sphex madraspatana Fab.); lunatum (Sphex lunata Fab.); cyaneum (Sphex cyanea Linné); and fuscum, a new species. The fourth species, Sphex cyanea Linné, had been placed in the genus Chrysis by Linné in the 12th edition of the Systema Naturae. The fifth species, described by Klug as fuscum, had already been described by Fabricius as Sphex hemiptera. None of these species was

designated by Klug as the genotype, and for nearly one hundred years the genus Sceliphron was without a designated type species.

The genus Pelopoeus was established by Latreille in 1802, giving as examples Sphex spirifex Linne, and Sphex lunata Fab., neither species being designated as the genotype. In 1810, Latreille (Cons. Gen., p. 38) gave spirifex as an "exempl" of the genus Pelopoeus, and these examples have been given the value of type designations by a ruling of the International Commission.

Bingham, however, in 1897, designated the same species, spirifex Linne as the type of the genus Sceliphron. These two genera, now having a common genotype, become synonymous, and Pelopoeus, described a year later than Sceliphron, must fall as a synonym.

The genus Sceliphron may be characterized briefly as follows: black and yellow, petiole slender, elongate, nearly as long as the entire thorax.

Sceliphron caementarium (Drury)

Sphex caementaria Drury Illustr. Nat. Hist.I., 1770, p. 105. ♀♂

Sphex flavomaculata Degeer. Mem. hist. Insect. III, 1773, p. 588 n, 4.

Sphex lunata Fabr. Syst. Entom. 1775, p. 347

Sphex flavipes Fabr. Spec. Insect. I. 1781, p. 444

Sphex flavipunctata Christ. Naturg. d. Insect. 1791, p. 301

Pelopoeus caementarius Westwood, Drury, Illustr. Nat. Hist. Ed. 2 a I 1837, p. 99.

Pelopoeus architectus (Klug) Lepeletier, Hist. nat. Insect. Hymen, III, 1845, p. 313 ♀

Pelopoeus servillei Lepeletier Hist. nat. Insect. Hymen, III, 1845, p. 313. ♀

Pelopoeus canadensis Smith, Cat. Hyman, Brit. Mus. IV, ~~IV~~, 1856, p. 233. ♂

Pelopoeus nigriventris Ach. Costa, Am. mus. Zool. Napoli, II (1862) 1864, p. 60.

Black and yellow, the amount of yellow being extremely variable. Legs always variegated with yellow; scape of antenna and the tegulae invariably yellow. Rest of body sometimes entirely black and sometimes with considerable yellow.

Female. Head: frons slightly depressed, insertion of antennae slightly elevated; upper part of clypeus somewhat convex; clypeus bidentate or bilobed at apex, the lobes rounded; frons except above antennae and clypeus covered with a dense black to golden pubescence; and also numerous upright black to brown hairs; antennae slender, filiform, the segments having the following relative lengths: 1/19, 2/5

3/27, 4/22, 5/17, 6/15, 7/13, 8/12, 9/10, 10/10, 11/9 12/10; scape yellow, bulb fuscous, remainder of antenna black, very minutely sericeous; mandibles very dark ferruginous to fuscous, slightly hairy towards the base, with longitudinal raised lines and furrows; frons above antennae, and vertex not or only slightly pubescent, but with numerous erect black to brown hairs; sparsely punctate; frontal suture not very distinct; gena and occiput weakly punctate, and covered with coarse, erect, black or brown hairs.

Thorax: surface of prothorax punctate, covered with long, erect, black to golden hairs; dorsal surface sometimes with a yellow spot, which may be interrupted in the middle. Mesonotum black, hairy, densely punctate, and sometimes striate, lateral edges slightly reflexed from tegulae back; tegulae yellow; scutellum often with a yellow spot, longitudinally striate, hairy; upper part of meso-episternum often yellow; rest of meso-episternum and all of epimeron black; whole pleural and sternal region hairy, punctate, sometimes minutely striate; upper part of meso-epimeron a little less punctate and more strongly striate. Metathorax black, except the post-scutellum, which may have a median transverse yellow spot; upper part of metapleural region striate; the part just below almost entirely smooth and without hairs; posterior portion of metathorax somewhat punctate and striate, not very definitely marked off above from the median segment.

Median segment: black with often more or less yellow; sometimes with three spots of yellow--one at end of segment and one at each side just anterior to the spiracles; sometimes with only one sometimes with two at end of segment, the rest being black; hairy, punctate and finely striate, the striae running obliquely up the sides and across the dorsum.

Abdomen: petiole smooth, non-punctate, or only very slightly so, minutely sericeous, black, yellow, or black dorsally and yellow ventrally, abdomen ovate, pointed at apex; black, except the first dorsal segment, which may have an irregular spot of yellow, or a smaller spot on each side; smooth, and no more than slightly sericeous except the last dorsal and ventral segments, which are sparsely hairy and punctate.

Legs. Anterior four: coxae, black; trochanters black with a yellow apical rim on the posterior and inner side; femora black proximally, yellow distally; tibiae yellow; tarsi yellow at base, the outer segments becoming fuscous. Hind legs: coxae black, trochanters usually black, (rarely fuscous or ferruginous) with a yellow apical rim on inner side; femora black, tibiae yellow basally, black distally; tarsi yellow at base, the outer segments becoming fuscous. Coxae and trochanters of all legs sparsely hairy; entire surface of legs more or less sericeous; tarsal claws ferruginous to fuscous, with a minute tooth near the middle

on the inner surface; spines on legs varying from yellow to fuscous.

Wings: transparent with a yellowish to fuscous tinge; outer margins slightly infuscated; larger veins yellowish ferruginous to fuscous; wings often with a slight violet or purple reflection.

Male . Differs from female as follows: slightly smaller; abdomen shorter and less acute; teeth of clypeus more pointed.

Genitalia, See Figs. 16, 17, & 18.

Length: female 17-26 mm; male 13-23 mm.

Habitat: North, Central, Insular and South America. The most northern records I have of it are "Canada", Joliette, Canada; Michigan, and Washington. I have records as far south as the Barbadoes and Costa Rica. Cameron also reports it from Brazil.

Types. The only type known to be in existence is that of Smith's canadensis in the British Museum, where it was seen by Dr. Fernald in 1913.

This species comes closer to figulum than to any other species. Sceliphron caementarium always has at least the basal half of the hind tibiae and the basal two segments of the hind tarsi yellow; whereas figulum has the hing legs almost entirely black or fuscous, the tibiae having a slight yellow streak below basally, and the two or three basal segments of the tarsus sometimes becoming yellowish. Also, with figulum the teeth of the clypeus of the male are often

very elongate and narrow, which is not the case with caementarium.

It has already been stated that the amount of yellow present in this species is very variable. This has led to its description under a number of different names, some being designated as distinct species, and others as varieties or subspecies. With a large number of specimens, taken from many parts of America, it has been possible to show that the whole group is one species, though with a great amount of variation.

The amount of yellow present on the legs seems to be very nearly constant. The scape of the antenna and the tegulae are always yellow. The abdomen, except the first dorsal segment and the petiole, is always black. The variation, then, occurs chiefly on the thorax, petiole, and first abdominal segment.

Beginning with the type having the largest amount of yellow, we have servillei, described by Lepeletier in 1845. In this the yellow is distributed as follows: the dorsal part of the prothorax, tegulae, a streak downward below the tegulae, scutellum, post-scutellum, a spot on each side of the median segment anterior to the spiracles, a very large spot at end of median segment, this sometimes very much produced forwards, the entire petiole, and almost all of the first dorsal abdominal segment. In some the petiole, instead of being entirely

yellow, has a fuscous streak on the dorsal side; in others there is a definite black streak in the same place, and in still others almost the dorsal half is black. Parallel with this has occurred a reduction in the size of the spots on the median segment, those at the sides tending to disappear, and that on the end being much smaller. Such specimens were described as Sphex caementaria by Drury in 1770, and as Sphex flavipunctata by Christ. in 1791.

Next we find theamount of yellow on the ventral side of the petiole gradually disappearing until it becomes entirely black. Specimens showing this condition were described in 1773 by DeGeer as Sphex flavomaculata and by Fabricius in 1775 as Sphex lunata.

From this point on, the reduction in amount of yellow seems to take place in two main regions--at the end of the median segment, and on the first dorsal abdominal segment. The spot at the end of the median segment is very much reduced in size in some specimens, and in some is narrowed in the middle. In still others it is divided, forming two separate small spots instead of one larger one. This variation was described by Smith in 1856 as canadensis. In other specimens the spot or spots at the end of the median segment have completely disappeared, giving us a variation which has not been described.

Other specimens which retain the spot at the end of the median segment, lose to a greater or less extent the yellow

on the first dorsal segment of the abdomen. The lunate mark becomes divided in the middle, and the two spots thus formed may become reduced to mere dots, or disappear entirely. This variation was described in 1864 by Ach. Costa as (Pelopoeus) nigriventris and in 1845 by Lepeletier as (Pelopoeus) architectus.

Parallel with the reduction in the amount of yellow on the median segment and abdomen has occurred a similar reduction in the amount on the dorsal surface of the thorax and on the meso-epimeron. When the yellow has all disappeared except that on the tegulae, we have the variation described by Fabricius as (Sphex) flavipes. Saussaure speaks of variations of flavipes where there is present a yellow sub-alar mark and others in which the scutellum and post-scutellum may have yellow fasciae.

From this series, it is evident that there is a gradual variation from the servillei form, with a large amount of yellow, down to the flavipes variation with no yellow except on the legs, tegulae and scapes of antennae. A detailed study of the genitalia of the males has shown that the genital structures are identical throughout the group and there are no essential structural differences found in this series. It is thus evident that this whole group consists of but one species, first described by Drury as caementarium.

Sceliphron figulum (Dahlbom)

Pelopoeus figulus (Westermann) Dahlbom, Hymen. Europ. I, 1843, p. 23, n. 6. ♀

Pelopoeus assimilis Dahlbom Hymen, Europ. I, 1843, p. 23, n. 7 ♀ ♂

Pelopoeus vindex Lepeletier Hist. nat. Insect. Hymen III, 1845, p. 317, n. 17 ♂

Pelopoeus bimaculatus Lepeletier Hist. nat. Insect. Hymen. III, 1845, p. 319, n. 19 ♀

Pelopoeus chilensis Spinola, Gay: Hist. fis. Chile Zool. VI, 1851, p. 395, N. 1. ♀ ♂

Black and yellow, the yellow distributed as follows: scape of antenna, dorsal region of prothorax, scutellum, post-scutellum, tegula, a streak below the tegula, usually a spot on each side and one at the end of median segment, sometimes the ventral half of petiole, an irregular spot or spots on first dorsal abdominal segment, and parts of anterior four legs.

Female Head: frons slightly concave, insertion of antennae slightly elevated; anterior margin bilobed or bidentate, the lobes rounded; frons except above antennae and clypeus covered with a dense golden pubescence, and also numerous upright black to golden hairs; antennae slender, filiform, the segments having the following

relative lengths: 1/19, 2/4, 3/26, 4/22, 5/17, 6/14, 7/12, 8/11, 9/10, 10/10, 11/9, 12/10; scape yellow, bulb fuscous, the remainder of antenna black, very minutely sericeous; mandibles very dark ferruginous to fuscous, slightly hairy towards the base, with longitudinal raised lines and furrows; frons above vertex, antennae, genae, and occiput, not or only slightly pubescent but with numerous erect black to golden hairs, and weakly punctate.

Thorax: Dorsal region of prothorax with a large yellow spot; surface weakly punctate, covered with long, erect, black to golden hairs. Mesonotum black, hairy, densely punctate, and sometimes striate; scutellum transverse, with a large yellow spot, longitudinally striate, hairy; tegulae yellow; upper part of meso-episternum yellow; rest of meso-episternum and all of meso-epimeron black; whole pleural and sternal region hairy, punctate, sometimes minutely striate; upper part of meso-epimeron a little less punctate and more strongly striate. Metathorax black except the post-scutellum, which has a linear transverse yellow spot; upper and anterior part of metapleural region striate; the part just below almost entirely smooth and without hairs; posterior portion of metathorax somewhat punctate and striate, not very definitely marked off above from the median segment.

Median segment: hairy, punctate and striate, black, usually with three yellow spots--one on each side anterior to the spiracle, and one at the end above the petiole, this spot varying greatly in size, but usually covering the whole end of the segment and extending forward on the dorsum leaving a central black band which in front widens to the full width of the dorsum--(I have one specimen from Chile in which the median segment is almost entirely black, suggesting the possibility of a variation similar to that occurring in caementarium).

Abdomen: petiole smooth, non-punctate, or only very slightly so, faintly sericeous, black, sometimes with the ventral portion yellow; abdomen ovate, pointed at apex, black except the first dorsal segment, which has an irregular yellow mark, sometimes interrupted in the middle; smooth, and no more than slightly sericeous except the last dorsal and ventral segments, which are sparsely hairy and punctate.

Legs: anterior four: coxae black; trochanters black with a yellow apical rim behind; femora black proximally yellow distally; tibiae yellow; tarsi yellow at base, the outer segments becoming fuscous. Hind legs: almost entirely black; trochanters with a yellow apical rim on inner side and sometimes with a small spot of yellow on outside; tibiae with an inconspicuous yellow streak on lower surface baseally; tarsi sometimes fuscous with the first segment or two ferruginous below instead of black. Coxae and trochanters of all legs sparsely hairy; entire surface of legs more or less

sericeous; tarsal claws fuscous, with a very minute tooth near the middle on the inner surface; spines on legs varying fromyellow to fuscous.

Wings: transparent with a yellowish tinge; outer margins slightly infuscated; larger veins yellowish ferruginous to fuscous. In wings which are the most fuscous there is a slight violet or purple reflection.

Male. Differs from female as follows: slightly smaller; abdomen shorter and less acute; teeth of clypeus usually more pointed than those of the female, but vary in a marked degree some being very elongate, and others shorter and not as pointed.

Genitalia: similar to those of P. caementarium, but tips of uncus are longer, more slender, and do not curve back as much.

Length: female, 19-25 mm; male 17-24 mm.

Habitat: North, Central, Insular, and South America. The most northern record I have is Brownsville, Texas. Specimens have been taken in Cuba, Jamaica, and Trinidad and from several places in Mexico and Central America. In South America, specimens have been recorded from Para, Brazil; Ecuador, Colombia, Chile, and Bahia Blanca, Argentina, this last being the most southern record which has come to my notice.

Types: The type of assimilis was studied by Dr. Fernald in the University of Lund in 1913. The location of the other types is unknown.

The original descriptions of figulum and assimile by Dahlbom are extremely meagre, but could apply to no other species of Sceliphron than the one here described; the two were separated by Dahlbom on the basis of the color of the wings, those of figulum being dull yellow brown and those of assimilis being fuscous. Since there are such varying shades of ferruginous and fuscous in the wings of this species, it seems very likely that Dahlbom described the same species under two names. The descriptions of bimaculatus and vindex by Lepeletier are identical in almost ~~in almost~~ every respect and also with those of figulus and assimilis by Dahlbom as far as they go, and there is no question as to their identity. About chilensis I am somewhat in doubt. As described by Spinola this species differs from figulum only in having the median segment entirely black instead of with three spots of yellow. Only one specimen from Chile was available for study; this specimen had two faint dots of yellow at the end of the median segment and none at the sides. Since these spots are likely to vary greatly in size, it is reasonable to suppose that they may entirely disappear in some cases, as occurs in caementarium. With other specimens from southern South America, it would be possible to determine whether or not chilensis could be included within the range of variation of this species.

The differances between this species and Sceliphron caementarium have already been noted under the description of that species. Superficially, figulum resembles fistulare, but with fistulare, the median segment is marked off below from the metathorax by a deep, definite groove, and the median segment has six spots of yellow, neither of these features being found in figulum.

Sceliphron fistulare (Dahlbom)

Pelopoeus fistularis Dahlbom. Hymen. Europe I, 1843, p. 22. n. 8, 1845, p. 434, n. 17. ♀♂

Pelopoeus histrio Lepeletier, Hist. nat. Insect. Hymen III, 1845, p. 316 n. 16 ♀♂

Black and yellow; median segment shining, strongly striate, and with six spots of yellow; pubescence golden; tarsal claws without a tooth, median segment definitely marked off below from the metahorax by a deep groove.

Female Head: frons depressed, insertion of antennae slightly elevated; upper part of clypeus slightly convex; clypeus bidentate or bilobed at apex, the lobes rounded; frons except above antennae and clypeus covered with a dense golden pubescence; and also numerous erect golden hairs; antennae slender, filiform, the segments having the following relative lengths: 1/21, 2/4, 3/25, 4/21, 5/17, 6/14, 7/11, 8/10, 9/9, 10/9, 11/8, 12/10; scape yellow, bulb fuscous,

remainder of antenna black, very minutely sericeous; mandibles very dark ferruginous to fuscous, without a tooth on inner surface, slightly hairy towards the base; frons above antennae; vertex, genae, and occiput not or only slightly pubescent, but with numerous erect golden hairs, weakly punctate.

Thorax: surface of prothorax weakly punctate, covered with long, erect, golden hairs; dorsal surface with a yellow spot; sometimes a yellow spot at each side. Mesonotum black, hairy, densely punctate, minutely striate; tegulae yellow; scutellum with a large yellow spot, longitudinally striate, hairy; upper part of meso-episternum yellow, rest of meso-episternum and all of meso-epimeron shining black; whole pleural and sternal region hairy, punctate but not striate. Metathorax smooth, or at most only very weakly and sparsely punctate, shining black, except the post-scutellum, which has a linear transverse spot of yellow; metathorax very definitely marked off above from the median segment.

Median segment: shining, black, hairy, not noticeably punctate but quite strongly striate, with six spots of yellow--one on each side anterior to and extending backward below the spiracles, one on each side of the median line of the dorsum, and two at the end above the base of the petiole; ~~fuscous; without a tooth~~.

Abdomen: petiole black, with a narrow yellow line on the ventral surface, almost entirely smooth; first dorsal segment with a yellow spot, which is larger at the sides; rest of abdomen black, smooth, and no more than slightly sericeous except the last dorsal and ventral segments, which are sparsely hairy and punctate.

Legs: anterior four: coxae black; trochanters black with a yellow apical rim posteriorly and on the outside, often with a yellow spot on anterior surface; femora with a small area of black basally, the remainder yellow; tibiae yellow; tarsi yellow, the outer segments becoming fuscous. Hind legs: coxae black with a sub-quadrate spot of yellow behind and often another spot on the opposite side, the two sometimes meeting; trochanters black to fuscous, with sometimes an indefinite yellowish area, femora black to fuscous with a narrow yellow line outside; tibiae fuscous, yellow below distally; tarsi fuscous. Coxae and trochanters very sparsely hairy; surface of legs more or less sericeous, that of the tarsi and tibiae especially so; spines fuscous to ferruginous; tarsal claws fuscous, without a tooth.

Wings: transparent with a yellowish to fuscous tinge; outer margins slightly infuscated; veins fusco-ferruginous; wings often with a slight violet reflection.

Male. Differs from female as follows: slightly smaller; abdomen shorter and less acute; teeth of clypeus not broadly rounded; but pointed (not so much so, however, as in caementarium or figulum.)

Genitalia. Tips of uncus curving gradually, blunt, not pointed. Sagittae, volsellae, and claspers somewhat similar to those of S. caementarium. (Plate IV, figs. 19 and 20.)

Length:female, 20-24 mm; male 17-21 mm.

Habitat: Mexico, Central, Insular and South America. Cameron reports it as far north as Atoyac, Vera Cruz. The only record from Insular America is from Montserrat. I have specimens from Para and Obidos, Brazil; and one from Peru. How much farther south the range of this species extends I cannot say.

Types: The location of the types of this species is unknown.

Sceliphron fasciatum (Lepeletier)

Pelopoeus fasciatus Lepeletier, Hist. nat. Insect. Hymen, III, 1845, p. 315 n. 15. ♀

Pelopoeus argentifrons Cresson, Proc. Entom. Soc. Philadelphia, IV, 1865, p. 136 ♀

Shining black, with pale yellow markings on thorax and first dorsal abdominal segment, pubescence and hairs silvery, legs black.

Female Head; black, frons slightly depressed, insertion of antennae slightly elevated; upper part of clypeus somewhat convex, anterior edge reflexed, bidentate or bilobed, the lobes being rounded; frons except above antennae, and clypeus with a dense silvery pubescence and also with numerous erect silvery hairs; antennae black, faintly sericeous, the segments having the following relative lengths: 1/19, 2/4, 3/24, 4/18, 5/15, 6/13, 7/11, 8/9, 9/8, 10/7, 11/6, 12/7; mandibles fuscous, tips ferruginous, sparsely hairy towards the base; frons above antennae, vertex, genae and occiput, not or only slightly pubescent, but with numerous erect, silvery hairs, slightly punctate.

Thorax: prothorax shining black, with two linear spots of yellow on the dorsal surface, one on each side of the median depression, weakly punctate, covered with white hairs. Mesonotum

black, densely and finely punctate and striate, hairy; scutellum with a transverse yellow spot, longitudinally striate; upper part of meso-episternum yellow; rest of meso-episternum and all of meso-epimeron shining black; whole pleural and sternal region hairy, punctate and striate. Metathorax black except a narrow transverse band of yellow on the post-scutellum; upper and anterior part of metapleural region almost smooth and with only a few minute white hairs; posterior part slightly punctate.

Median segment: shining black with a spot of yellow on each side just anterior to the spiracles, and two sub-circular spots of yellow at apex, above the base of the petiole, minutely punctate and striate, covered with silvery hairs.

Abdomen: petiole shining black, slightly hairy and sericeous; abdomen ovate, pointed at apex, black except the first dorsal segment, which has a yellow band on its posterior margin, broadening out at the sides, non-punctate and not more than very slightly sericeous except the last dorsal and ventral segments, which are hairy and punctate.

Legs black, more or less silvery sericeous, the tarsi being especially so; coxae and trochanters and sometimes the femora, sparsely hairy; tarsal claws dark ferruginous, with a minute tooth near the middle on the inner surface; spines on legs fuscous.

Wings: transparent with a fuscous tinge, outer margins infuscated; veins fuscous; wings often with a slight violet or purple refection.

Male. Differs from female as follows: anterior margin of clypeus nearly straight; anterior tibiae usually with an

elongate yellow spot; middle tibiae often with a very small yellow spot.

Genitalia: uncus slender, tips bent at right angles to main axis; volsellae broad. (Plate IV, figs. 21 and 22).

Length: female, 19-22 mm; male 17-19 mm.

Habitat. Isle of Pines, Hayti and Cuba.

Types. The location of Lepeletier's type is unknown. The type of Cresson's argentifrons is in the collection of the Entomological Society of Philadelphia.

This species seems to be very distinct from all other American species of Sceliphron.

Sceliphron jamaicensis (Fabricius)

Sphex jamaicensis Fabricius Syst. entom. 1775, p. 347, n. 10.

Pelopoeus jamaicensis Fabricius. Syst. Piez. 1804, p. 204, n. 6.

Pelopoeus annulatus, Cresson, Proc. Entom. Soc. Philadelphia, IV, 1865, p. 135. ♀ ♂

Types: black or fuscous and yellow, posterior margins of all abdominal segments yellow; pubescence and hairs golden.

Female. Head: frons slightly depressed, insertion of antennae slightly elevated; upper part of clypeus somewhat convex; clypeus bidentate or bilobed at apex, the lobes rounded; frons except above antennae, and clypeus covered with a dense golden pubescence and numerous erect golden hairs; antennae

slender, filiform, the segments having the following relative lengths: 1/20, 2/5, 3/25, 4/20, 5/17, 6/14, 7/11, 8/10, 9/10, 10/9, 11/8, 12/9; scape yellow, bulb fuscous; second segment fuscous above, yellow below; 3rd segment yellow basally below and at tip, rest fuscous; 4th and 5th segment sometimes slightly yellow at tip; rest of antennae black, very minutely sericeous; mandibles very dark ferruginous to fuscous, slightly hairy towards the base, frons above antennae vertex, genae, and occiput not or only slightly pubescent, but with numerous erect golden hairs, somewhat punctate.

Thorax: surface of prothorax punctate, covered with long, erect, golden hairs; dorsal surface almost completely covered with a yellow spot, which usually extends downward on each side nearly to the coxa. Mesonotum black, hairy, densely punctate, minutely striate; tegulae yellow; scutellum with a large transverse yellow spot, longitudinally striate; upper part of meso-episternum yellow; rest of meso-episternum and all of meso-epimeron black; whole pleural and sternal region hairy punctate, sometimes minutely striate; upper part of meso-epimeron a little less punctate and more strongly striate. Metathorax black except the post-scutellum, which has a transverse yellow spot; upper and anterior portion of metapleural region almost entirely smooth and without hairs; posterior portion of metathorax not very definitely marked off above from the median segment.

Median segment: black with three yellow spots--one on each side at the anterior end each of these extending downwards and posteriorly to a point--and one at the end of the median segment and extending forward on the dorsum, leaving a central black band which in front widens out to the full width of the dorsum; median segment punctate and finely striate.

Abdomen: petiole smooth, non-punctate or only very slightly so, minutely sericeous, black dorsally and yellow ventrally, the limits of black and yellow varying greatly; abdomen ovate, pointed at apex; first segment yellow, with a fuscous stain above the petiole; rest of segments fuscous to black, posterior margins yellow; abdomen smooth, and no more than slightly sericeous except the last dorsal and ventral segments, which are sparsely hairy and punctate.

Legs: Anterior four: coxae black; trochanters black with a yellow apical rim on outside; femora black basally, the remainder yellow; tibiae yellow; tarsi yellow at base, the outer segments becoming fuscous. Hind legs: coxae black; trochanters yellow with a fuscous apical rim; femora yellow basally, the remainder black; tibiae yellow basally, black distally; tarsi yellow and fuscous, first segment usually fuscous at base and apex; the others yellow at base and fuscous at apex, outer segments becoming entirely fuscous. Coxae and trochanters very sparsely hairy; entire surface of legs more or less sericeous; tarsal claws fuscous, with a

minute tooth near the middle on the inner surface; spines on legs varying from yellow to fuscous.

Wings: transparent with a yellowish to ferruginous tinge; outer margins slightly infuscated; wings sometimes with an extremely slight violet or purple reflection.

Male. Since no males were available for study I quote from Cresson's description:

"Colored like the female except that the abdomen beyond the first segment is fusco-ferruginous, with the apical margins faintly paler."

Length: female, 19-23 mm.

Habitat: Hayti, The Bahamas, Cuba, Jamaica.

Types. The location of Fabricius's type is unknown. That of Cresson's annulatus is in the collection of the Entomological Society of Philadelphia.

As this species is the only one from Jamaica or the West Indies in which the segments of the abdomen are bordered with yellow, there seems to be little doubt that it was the one which Fabricius described as jamaicensis. Fabricius does not mention the presence of yellow on the petiole, but with the color variation that occurs throughout this genus, he may have described from a specimen in which the petiole was black or nearly so. Cresson's annulatus, therefore, is synonymous with jamaicensis.

This species is somewhat similar to Sceliphron lucae, but with lucae, the yellow borders of the abdominal segments are much wider. The two are also very widely separated geographically.

Sceliphron lucae (Saussure)

Pelopoeus lucae Saussaure, Reise, d. Novara, Zool. II. p. 1, 1867, Hymen, p. 30, n. 1. ♀ ♂

Black and yellow; posterior margins of all abdominal segments broadly yellow; pubescence and hairs all yellow.

Female. Head: frons slightly depressed, insertion of antennae slightly elevated; upper part of clypeus somewhat convex; clypeus bidentate or bilobed at apex, the lobes rounded; frons except above antennae and clypeus covered with a dense golden pubescence and numerous erect golden hairs; antennae slender, filiform, the segments having the following relative lengths: 1/24, 2/5, 3/27, 4/24, 5/18, 6/15, 7/12, 8/12, 9/11, 10/10, 11/9, 12/9; scape yellow, bulb fuscous; 2nd segment yellow; 3rd segment fuscous above, yellow below; the rest of antennae black, minutely sericeous; mandibles ferruginous to fuscous, sparsely hairy near base; frons above antennae, vertex, genae and occiput not or only slightly pubescent, but with numerous erect golden hairs, weakly punctate.

Thorax: Surface of prothorax weakly punctate, covered with long, erect, golden hairs; dorsal surface almost completely covered with a yellow spot; sides of the prothorax with another yellow spot. Mesonotum black, hairy, densely punctate, minutely striate; tegulae yellow; scutellum with a large transverse yellow spot, longitudinally striate; upper

part of meso-episternum yellow; rest of meso-episternum and all of meso-epimeron black,--except rarely a few small spots of brown; whole pleural and sternal region hairy, punctate. Metathorax black except the post-scutellum, which has a transverse yellow spot; upper and anterior portion of metapleural region nearly smooth and without hairs; posterior portion not very definitely marked off above from the median segment.

Median segment: black with three yellow spots--one on each side at the anterior end, each of these extending downwards and posteriorly to a point, and one at the end of the median segment extending forwards on both sides of and extending over upon the dorsum; median segment punctate, finely striate, and hairy.

Abdomen: petiole smooth, non-punctate, minutely sericeous in places, yellow to ferruginous; abdomen long, ovate, pointed at apex; first segment yellow, with a fusco-ferruginous stain above petiole; rest of segments black anteriorly, yellow posteriorly, smooth, and no more than slightly sericeous except the last dorsal and ventral segments, which are sparsely hairy and punctate.

Legs: Anterior Four: coxae black, often ferruginous at the tip; trochanters ferruginous; femora ferruginous at base to yellow at tip; tibiae yellow; tarsi yellow, the outer segments becoming ferruginous. Hind legs: coxae black, ferruginous at tip, trochanters ferruginous, femora ferruginous at base, the rest fuscous to black; tibiae yellow, black distally; tarsi yellow, outer segments, probably becoming ferruginous to fuscous. (Only two specimens were available,

and both of these lacked the last two tarsal segments). Coxae and trochanters very sparsely hairy; entire surface of legs more or less sericeous; tarsal claws ferruginous with a minute tooth near the middle on the inner surface; spines on legs varying from yellow to fuscous.

Wings: transparent with a ferruginous tinge; outer margins slightly infuscated; wings sometimes with an extremely slight violet reflection.

Male. Only one male was available for study, and that one was extremely small, and may have been abnormal in other respects. Differed from female as follows: petiole entirely black; teeth of clypeus more pointed; abdomen shorter and less acute.

Genitalia: practically the same as those of caementarium. Figs. 16, 17, & 18.)

Length: female, 20-24 mm; male, 14 mm. (Only one male was available for study; this was probably unusually small.)

Habitat: California, Lower California.

Type: Probably in the Saussaure collection at Geneva.

Unidentified and Other Species

The following species have been described as occurring within the geographical limits of this paper, but have been unrecognized or should be placed in other genera.

Sceliphron argentipile (Provancher)

Pelopoeus argentipilis Provancher. Addit. Faun. Canada, Hymen, 1887, p. 256. ♀

An examination of the type at Quebec by F. W. L. Sladen at the request of Dr. C. Gordon Hewitt proved it to be not a Sceliphron but presumably a Sphex.

Sceliphron fuscum (Lepeletier)

Pelopoeus fuscus Lepeletier, Hist. nat. Insect. Hymen, III. 1845, p. 311, n. 9. ♀

The habitat of this species is unknown. I have been unable to recognize this species, and it probably does not occur in America. Whatever its identity, Lepeletier's name fuscum must be rejected as a homonym, having been previously used by Klug for one of the species originally included in Sceliphron.

Sceliphron petiolatum (Drury)

Sphex petiolatus Drury, Illustr. Nat. Hist. II, 1773. p. 75; T. 39, F. 7.

Pelopoeus petiolatus Westwood, Drury: Illustr. Nat. Hist. Ed. 2a II, 1837, p. 85; T 39, F. 7.

This species was described by Drury from Jamaica. It has been unrecognized since, and I have been unable to place it. From a study of Drury's description and plates, I judge that this species is not a Sceliphron.

Explanation of Plates.

Plate I.

Fig. 1. Dorsal view of thorax of female S. caementarium.

Fig. 2. Side view of thorax and abdomen of female S. caementarium.

a. prothorax

al. prothoracic lobe

ac. anterior coxa

b1 mesonotum

b2 scutellum

b3 mesothoracic episternum

b4 mesothoracic epimeron

t tegula

fw fore wing

hw hind wing

c1 post-scutellum

c2 anterior portion of metathorax

c3 posterior portion of metathorax

mc middle coxa

pc posterior coxa

d1 dorsum of median segment

d2 side of median segment

d3 end of median segment

d4 spiracle in median segment

f funiculus

p. petiole

s. spiracle in 1st dorsal abdominal segment

Fig. 3 Front view of head of female S. caementarium.

Fig. 4. Tarsal claw of S. caementarium.

Fig. 5. Tarsal claw of S. fistulare.

Plate II.

Fig. 6. Wings of S. caementarium with the veins named according to the usual nomenclature.

a.	anal
ax	axillary
b	basal
c	costal
cu	cubital
d	discordal
f	fold
ff	frenal fold
fh	frenal hooks
m	median
r	radial
rel	first recurrent
re2	second recurrent
s	stigma
sc	subcostal
sd	subdiscoidal
si	sinus
tc	transverse cubital
tcl	first transverse cubital

tc2 second transverse cubital

tc3 third transverse cubital

tm transverse median

Fig. 7. Wings of S. caementarium with the cells named according to the usual nomenclature.

a anal

apl first apical

ap2 second apical

c costal

cu cubital

cul first cubital

cu2 second cubital

cu3 third cubital

cu4 fourth cubital

d1 first discoidal

d2 second discoidal

d3 third discoidal

m median

r radial

sm submedian

Fig. 8. Tip of anterior tibia and base of first tarsal segment of S. caementarium showing cleaning apparatus.

Fig. 9. Tip of posterior tibia and base of first tarsal segment of S. caementarium showing cleaning apparatus.

Plate III

Fig. 10. Clypeus of male S. caementarium.

Fig. 11. Clypeus of female S. caementarium.

Fig. 12. Clypeus of male S. fasciatum.

Fig. 13. Antenna of female S. Caementarium.

b bulb

s scape

p pedicel

fil filament

Fig. 14. Mandible of male S. caementarium.

Fig. 15. Mandible of female S. caementarium.

Fig. 16. Ventral view of genitalia of male S. caementarium.

co cardo

cla clasper

vo volsella

sa sagitta

u uncus

Plate IV - Male Genitalia

Fig. 17. Uncus of S. caementarium.

Fig. 18. Volsellae and sagittae of S. caementarium.

Fig. 19. Volsellae and sagittae of S. fistulare.

Fig. 20. Uncus of S. fistulare.

Fig. 21. Uncus of S. fasciatum.

Fig. 22. Volsellae and sagittae of S. fasciatum.

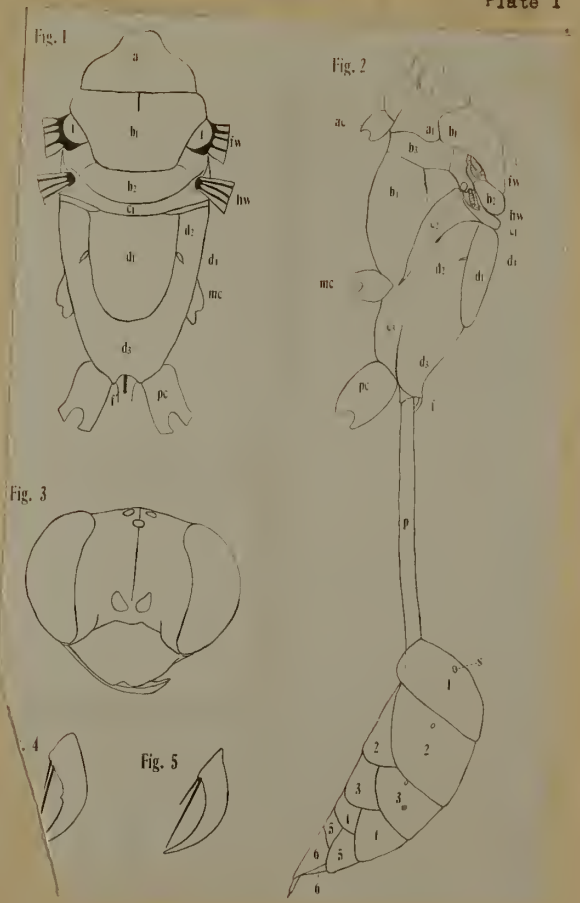


Fig. 1
a
b1
fw
b2
hw
c1
d2
d1
d3
mc
f1
pc
Fig. 2
ac
a1
b3
b1
b2
fw
hw
c1
c2
d3
d2
d1
mc
pc
f
p
1
2
3
4
5
6
Fig. 3
Fig. 4
Fig. 5

II

Fig. 6

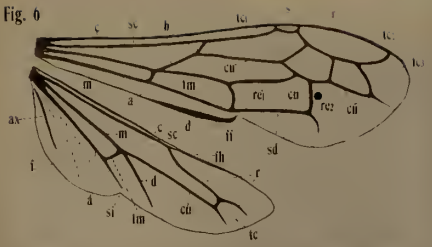


Fig. 7

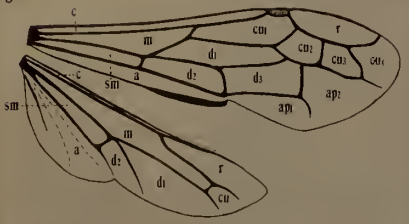


Fig. 8

Fig. 9

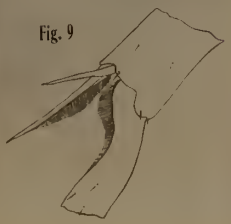


Plate III

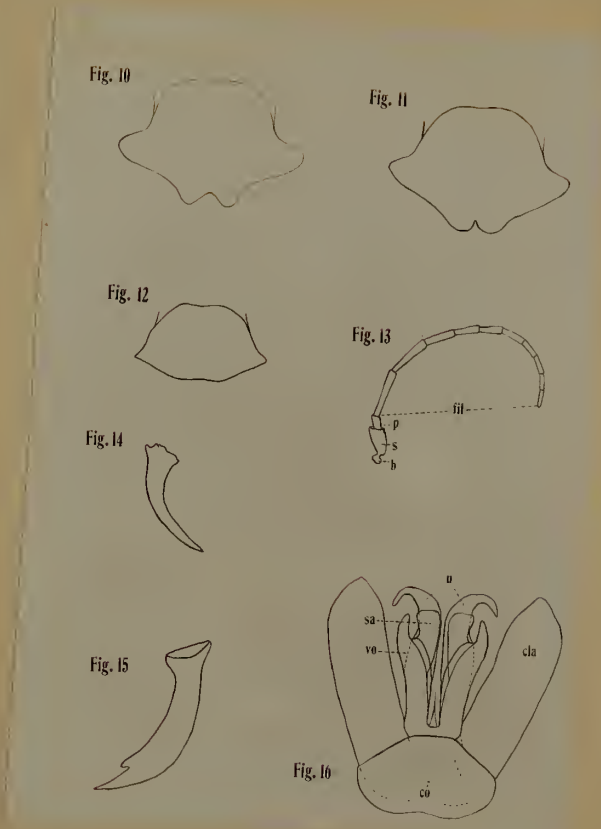
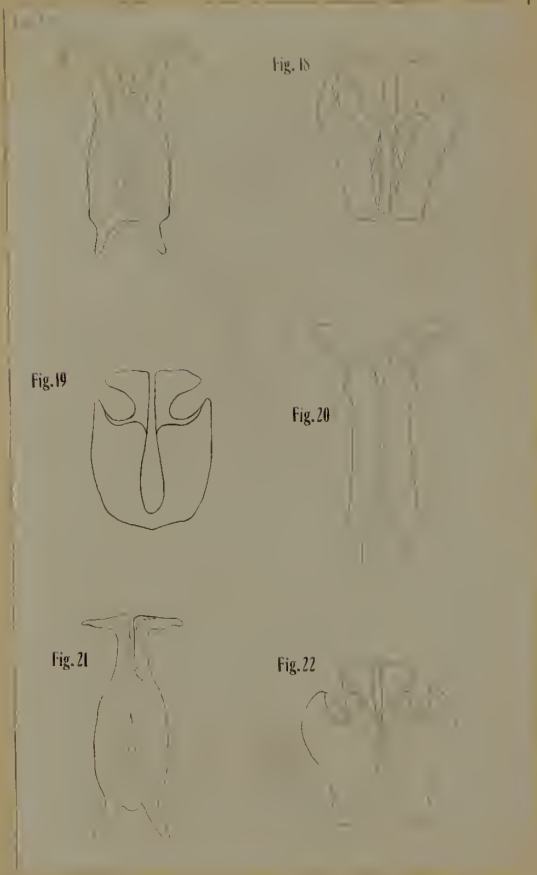


Fig. 10
Fig. 11
Fig. 12
Fig. 13
fil
p
s
b
Fig. 14
Fig. 15
Fig. 16
u
sa
ve
cla
co

Plate IV



THE SPRUCE
GALL LOUSE

(*CHERMES ABIETIS* L.)

INTRODUCTION

The study of the Spruce Gall Louse was suggested to the writer late in the summer of 1916 by Dr. H. T. Fernald. This insect had previously been studied by other observers, but Dr. Fernald was of the opinion that there was need of a thorough revision of our knowledge of its life history and the methods of controlling it. Most of the writer's time and attention have therefore been given to those two features; the rest of the paper has been partially drawn from other sources in order to present a well rounded account of this interesting insect. Preliminary notes on this species made by Mr. A. J. Flebut have been at the disposal of the writer, and were helpful. Many thanks are due to Dr. Fernald for his ceaseless interest in the work and for the use of his private library; to Dr. Guy C. Crampton for helpful suggestions, particularly regarding the anatomy of the insect studied; to W. S. Regan and A. I. Bourne for helpful suggestions; to Miss Edith Patch of the Maine Experiment Station and Professor C. P. Gillette of the Colorado Station for information concerning the host plants and distribution of this species.

COMMON NAME OF CHERMES ABIETIS L.

While several species of Chermes make galls upon the various spruces in New England, Chermes abietis L. is the species most commonly found in most localities. It has been called by a number of common names, such as "The European Spruce Bud-louse", "The Yellow Chermes," and the "Green-winged Chermes." The name in most common use, however, is the "spruce gall louse", and it will be referred to as such in this paper.

HISTORY OF THE SPRUCE GALL LOUSE

In Europe

Chermes abietis L. has been known in Europe ever since men began to notice the work of insects and to record their observations. Its present name was given it by Linné, in the tenth edition of his Systema Naturae, in 1758, but even previous to that time mention had been made of insects which produced galls on spruce, referring to this or an allied species. Linné did not enter into any detailed description of this insect or of its life history. Fifteen years later, in 1773, Degeer gave a lengthy and extremely accurate account of its life history, to which very little has since been added.

Throughout the European literature the various species of Chermes have been more or less confused, one particular instance of this being the case of abietis L. and viridis Ratz., which was described in 1844, and which was considered identical with abietis L. until 1896, when Cholodkovsky showed the two to be distinct, the one confining itself to the spruce, the other migrating for part of its life cycle to the larch. The fact that the galls made by both species on the spruce are almost identical doubtless led to the confusion.

Buckton, in his "British Aphididae", in 1890, gives a complete life history and description of the stages of Chermes abietis L., and also describes what he considers to be the male. Buckton's observations have since been discredited, and there seems no doubt that he was mistaken. Cholodkovsky, in 1907, gave an account of this species in "Die Coniferen-lause Chermes" together with a general discussion of the entire genus. Two years later, Professor Nusslin summed up the work done the preceding twenty years in his article "Die Neuen Ergebnisse und Aufgaben der Chermes-forshung" in the Zoologisches Zentralblatt for December, 1908.

In America

Chermes abietis L. was presumably introduced into the United States from Europe with the Norway Spruce, but the exact date of the introduction cannot be determined. In the literature, this species has been so confused with others, especially with pinifoliae Fitch and coolevi Gillette, that it is impossible to say what is the earliest reference to it. In 1869, Packard refers to the "Adelges of the spruce" in his "Guide to the study of Insects", and may mean abietis L., but it is more likely that he refers to pinifoliae Fitch, since he says that the galls were terminal, a characteristic of the latter species. Chermes abieticolens, mentioned by Thomas in 1876, which was merged by Cooley with abietis L., has since been shown to be distinct from abietis L., and identical with pinifoliae Fitch. In 1887, Oestlund, in his "Aphididae of Minnesota" lists Chermes abietis L. as occurring in America, but not in Minnesota. However, due to the confusion existing at that time regarding the identity of the different species, it is not certain that this list was entirely correct.

In 1897 Cooley published the first extensive American account of this insect, giving a full life history and description of stages. He considered abieticolens Thomas as synonymous with abietis, but this species was shown by Miss Patch in 1909 to be not abietis, but one stage in the life history of pinifoliae Fitch. Cooley also included a species from Colorado which has since been shown to be distinct, and described as Chermes

coolevi by Gillette. Many of the American accounts since 1897 have been based on that written by Cooley.

In 1909 Miss Patch published "The Chermes of Maine conifers," which included notes on Chermes abietis L. and as already mentioned, removed abiticolens from abietis and showed it to be identical with pinifoliae Fitch.

Synonymy of Chermes abietis L.

Buckton gives the following list of synonyms for Chermes abietis L.:

Chermes abietis L. Fab., Schr., Kirby and Spence, Kalt., Koch, Pass., Ratz., Leuckhart.

Adelges gallarum abietis Haliday.

Adelges abietis Walk.

Aphis gallarum abietis DeGeer, Burm.

Sacchiphantes abietis "Ruricola".

Elatiptus Amyot.

Other synonyms and names of species which have been confused with Chermes abietis L. are as follows:

Chermaphis Maskell. This name was proposed as a new generic name for Chermes.

Chermes viridis Ratz. Until 1896 confused with abietis.

Chermes abieticolens Thomas. Considered by Cooley to be synonymous with abietis, but shown in 1909 by Miss Patch to be identical with pinifoliae Fitch.

Chermes coolevi Gillette. Recorded by Cooley as abietis.

DISTRIBUTION

In America, this species seems to be confined chiefly to the Eastern portion of the Transition Zone. Cooley reported that it was present from the Atlantic to the Pacific, but some of his records refer to other species of Chermes. Professor C. P. Gillette recently stated in correspondence that he had no knowledge of its occurrence in Colorado. In view of the frequent occurrence of this pest in nurseries, however, it will probably be only a matter of time when it will make its way to all sections of the country where Norway and White spruces thrive, if indeed it has not already done so.

In Europe, Chermes abietis, L. has a very extensive distribution, being found as far nother as St. Petersburg and as far south as Parma, Italy.

HOST PLANTS

Unlike many closely related species, Chermes abietis L. has apparently no alternate host plant, and seems to confine its attacks to two species of spruce -- Picea abies, the Norway Spruce, and Picea alba, the white spruce. Records of its occurrence on the black spruce, Picea nigra, have been shown to refer to Chermes pinifoliae Fitch, and those of its occurrence on the Colorado blue spruce, Picea pungens, referred to Chermes cooleyi Gillette.

NATURE OF THE INJURY

As implied by the common name of this insect, the injury inflicted by it consists in the formation of a gall. This occurs in the spring, just as the buds are unfolding. The twig in most cases manages to grow through the gall, but seldom makes the growth that it would without being handicapped by the gall at its base. The twig is usually completely surrounded, but in some cases the gall is incompletely formed, only partially surrounding the twig, which in such cases is likely to be bent and distorted.

ECONOMIC IMPORTANCE

The spruce gall louse is of importance chiefly as a pest of ornamental trees. The injury consists in the formation of galls, as already described, which at least distort and disfigure the tree, and when very abundant seriously retard its growth. In extreme cases the tree infested may be killed. Miss Patch reports an instance where a single spruce three feet tall showed 990 fresh galls, making further growth well-nigh impossible. One spruce hedge under the observation of the writer has been entirely killed in spots and rendered unsightly and uneven throughout as a result of attack by this pest.

DESCRIPTIONS, LIFE HISTORY, AND HABITS

Brief Outline. Before presenting in detail the life history and habits of this species, it seems desirable to outline briefly its life cycle.

The full grown nymphs emerge from the galls in late summer and early fall, molt, and give rise to the winged females, which lay eggs. From these eggs hatch the young insects which settle down in various places, chiefly at the bases of the buds, insert their setae, secrete a quantity of waxy material over their bodies, and spend the winter in this condition. In the spring the surviving insects pass through three molts, growing rapidly, and lay a large number of eggs about the Middle of May. From these eggs hatch the young which enter into the galls already forming for their reception. The greater part of the summer is spent within the cavities in these galls. The life cycle is complete within one year.

Following this brief account is a detailed presentation of the life history and habits of this interesting insect.

The gall. As will be seen later, the galls are evidently started by the feeding punctures of the overwintering females, but the exact nature of the stimulus is unknown. The beginning of the gall can be seen before the hatching of the young which are to live in it. It is formed by the enlargement of the basal portions of the unfolding young needles, making a fleshy mass into which the young enter on hatching. Externally the

galls have been said to resemble miniature pineapples. They vary from one-half inch to an inch or more in length, and from one-half to three-fourths of an inch in thickness. The cells sometimes number as many as fifty. After the newly hatched Chermes have entered the galls, the cells close over or grow together externally, leaving a line shaped like an inverted V. The gall is green in color, and the lines marking the entrances to the galls are frequently tinted with a color varying from a pink to a purple.

The opening of the galls. In midsummer, or later, the galls begin to dry up, causing the mouths of the cavities to open, whereupon the nymphs, at this time full-grown, soon crawl out. The writer has been unable personally to note the time when most of the galls open, but Cooley says that this occurs in Amherst early in August, and Miss Patch gives the time for Orono, Maine, as the middle of August. The opening of the galls evidently covers quite a period of time, because on September 21, 1916, when the writer's observations began, a majority of them had opened, but here and there could be found galls, usually smaller than the rest, which were still closed, and it was as late as the middle of October before all were open.

At the time of the opening of the galls, the cavities in them have become quite crowded with the nymphs and their cast skins, which, when the insects are carefully removed, will be found attached to the posterior end of the body. These cast skins are distended with liquid passed from the insects, and

thus resemble the insects themselves. Since three cast skins is the greatest number found attached to any one nymph, it has been assumed that three molts usually occur within the gall. The interior is lined with a rosy-colored, pulverulent, waxy material similar to that covering the last stage nymphs as they emerge.

The last stage nymphs. These vary in length from 1.60 mm. to 1.90 mm. and from .80 mm. to .90 mm. in width. They are of a pale rosy color, sometimes with a yellowish tinge, especially on the head and thorax and are more or less covered with a waxy powder. The wing pads show greenish. The eyes are black, and the legs and antennae yellowish. The antennae consist of three segments.

They emerge slowly from the galls and make their way to nearby needles, where they molt in a very short time and transform into the winged females. Before molting, they attach themselves firmly to the needle, and when the winged form has emerged, the cast skin remains attached until finally dislodged by wind or rain.

The winged females. The newly emerged females are yellowish brown, turning darker later on. The fore wings are green at the base and the thickened anterior portion, while the remainder of the wing is practically transparent. The legs are pale yellowish green; the eyes are black, ocelli are present, the antennae are five-segmented. The abdomen has on it a small amount of waxy secretion. The body, exclusive of wings, is 1.70 mm. to 1.90 mm. in

length and .70 mm. to .90 mm. in width. The spread of the wings is about 5.25 mm.

Soon after emergence, the winged forms attach themselves to the needles, frequently the very one upon which the last molt occurred, and commence to lay eggs. Their powers of flight seems to be comparatively slight, and they seem to prefer to settle right down where they find themselves on molting, which is probably due to the fact that this species does not migrate to any other host plant. I have failed to observe the phenomenon recorded by Buckton, who says: "A gleam of bright sunshine will call them forth in clouds, each insect taking wing with a whirling motion, and a 'buzz' very loud for a body so small." Can it be that Buckton had under observation Chermes viridis Ratz., which at that time was confused with abietis, and which has since been shown to be a distinct form which migrates to the larch? It is not unusual to see spruces quite close together, some of which will be literally covered with galls, while others nearly touching them will have very few or none at all. The spread of the winged forms will always be very slow, unless strong winds arise just before the time when the majority of them have fastened themselves to the needles, and it is rather doubtful if these fragile creatures would be carried very far even in these circumstances. Some of the winged females settle down facing the base of the needle, while others face in the opposite direction. Often several may be found on the same needle.

The fall egg stage. Soon after fastening themselves to the needles, the winged adults begin to lay eggs, fastening each one to the needle by a very fine thread about the length of the egg itself. As the eggs are laid, the abdomen shrinks, until, when the process is completed, very little remains of it, and the eggs are protected by the wings of the mother insect. The eggs are covered by a small amount of waxy, cottony, secretion, as well as by the wings of the dead mother, and this protection remains in place for a long time after the young have hatched, sometimes even until the following spring. The number of eggs laid by the winged females varies from twenty to fifty. The individual eggs are yellowish brown in color and elongate oval in form, measuring about .40 mm. in length and .23 mm. in width.

Hatching of the fall eggs. The writer's observations on the period required for the hatching of these eggs differs somewhat from all published accounts examined, most of which state that two weeks are required. The writer has found that, while a majority of the eggs hatch in about two weeks, some may require at least five. To settle this point more definitely, a gall which was just beginning to open was brought in and placed under observation on September 25. On September 27, a dozen winged females appeared and began to lay eggs, which were immediately placed under conditions as nearly normal as possible. On October 6 - nine days after the eggs were laid-a few newly hatched young appeared. Many of the eggs hatched during the following week, but a few young appeared from day to day until November 1st,

after which time no more hatched. Practically all the eggs on the trees were hatched by that date, the few remaining unhatched eggs being for the most part dried and blackened. In the fall of 1915, according to observations made by Mr. Flebut, most of the hatching of the eggs took place later still, many of the eggs hatching about the middle of November, the latest definite date being November 24. In the fall of 1916, the first crawling young appeared September 25.

From the observations recorded above, it is evident that the time of emergence of the winged adults, the laying of the eggs, and the hatching of the young varies greatly with the season and with different individuals in the same locality, also that these stages may cover quite a long period of time.

Hibernating young. Upon hatching, the young insects are rather active. They make their way around among the needles, under the bud scales, and to all parts of the twig, but soon insert their setae into the plant tissue and settle down. Those which find their way into the buds among the bud scales, and those which settle upon the needles, apparently fail to find sufficient nourishment, since no live Chermes are to be found in such locations late in the season. Very few are found on wood over a year old. Most of them settle down at the bases of the buds. They soon secrete over their bodies quite a quantity of cottony material which serves as a protection during the winter. The setae are very firmly inserted into the plant tissue, which makes

it quite difficult to remove one of the insects for study without breaking them. In the condition described above, the young Chermes pass the winter without changing much in size or form, and apparently without shifting position.

The hibernating young are very small, being about .40 mm in length. They are ovoid in shape, the anterior end being somewhat broader, and of an olive green color, with darker patches where the wax pore areas are found. The antennae consist of three segments.

Spring period of growth. The "stem mother." Early spring finds many of the hibernating insects dead, more of those locating at the bases of the buds seeming to survive than of those attempting to winter in other places. The survivors have apparently undergone no change during the winter, and no change seems to take place in the spring until the last two weeks in April, when the young Chermes first molt, and then begin to grow with great rapidity. The first molted individuals found in Amherst in the spring of 1917 were observed on April 23rd, but that particular season was notably cold and backward, and it is probable that the first molt usually occurs a week or more sooner in the average season. In the process of molting, the skin apparently splits along the anterior and ventral median line, and is then pushed upwards and backwards by the rapidly growing waxy secretion which is formed very profusely at this stage. After molting, the young Chermes presents a very different appearance, being shorter and more nearly round. The color varies from a light to a very dark green. The wax pore areas are not nearly as noticeable in this stage as in the form which has hibernated.

The molt described above is rapidly followed by a second and a third. No attempt has been made to determine the length of these instars, but they follow each other in rapid succession. It is possible that not all individuals molt as many as three times, but in many cases, the three cast skins are found in a mass above or slightly pushed back from the individual which has cast them. The white, waxy filaments secreted in the spring stages are of a much finer texture than those secreted by the hibernating form. When full grown, the "stem mother", as individuals in this stage are sometimes called, measures about 1.33 mm in length and 1.17 mm in width.

Spring egg stage. At the close of the short period of rapid growth described above, the full grown females commence to lay eggs. In the spring of 1917, the first observed were on May 14th, but, as elsewhere noted, the cold and wet season doubtless delayed developments at least a week. Cooley gives as the first date May 9th. Each female lays from one hundred to three hundred or more eggs, usually in a heap in one spot, although in a number of instances noted, they were scattered here and there about the bases of the swelling buds, showing that the female had crawled about during the egg-laying process. The eggs vary in color from yellowish green to an olive green, and are somewhat similar to those laid in the fall, and are similarly attached to the bark by a transparent thread. They measure about .29 mm in length and .16 mm in width, and the thread by which they are attached is about twice the length of the egg. Under usual spring conditions, the eggs are said to hatch

in about a week, but in May, 1917, the weather continued unseasonably cold and wet, without doubt retarding the incubation of the eggs, because three weeks elapsed between the first appearance of the eggs and the first appearance of the young in the field. A few kept in the warmth of the laboratory hatched in six days, but those under field conditions required at least two weeks, and most of them three.

Formation of the gall. Before the eggs have hatched, and often before they have been laid, the gall to be inhabited by the resulting Chermes has already begun to form. If an unfolding bud having at its base a "stem mother" completing her growth or laying her eggs is cut in longitudinal section, the young needles will be found to be each very much enlarged at its base. As the young shoot unfolds from the bud, these swellings increase in size, and by the time the eggs hatch, a rapidly forming gall is ready for occupancy. The stimulus causing the formation of the gall has therefore been furnished by the egg-laying female, rather than by the young Chermes which receives the benefit and protection of it.

The gall-inhabiting form. Almost immediately on hatching, the young insects make their way among the rapidly swelling needles which together form the fleshy gall. At this time, they are about the same length as the egg, a little broader, flattened, yellow in color, becoming somewhat green after feeding for a time in the gall. The eyes are black, the legs and antennae are slightly dusky except at the tips, which are lighter. As soon as the young have entered, and sometimes, indeed, before that time, the cavities in the gall gradually close, leaving merely an inverted V-shaped line marking the place.

The life history of this insect gives us a very interesting and remarkable case of insect adaptation. The young Chermes which are to occupy the gall seem to hatch at almost the exact moment when conditions are most favorable for them. The gall is rapidly forming from the tender, succulent young needles which have been caused to swell by the presence of the "stem mother". Her offspring on hatching has simply to step inside the rapidly growing gall, where it is immediately surrounded by the very choicest of food material and is protected from all possible enemies. This species seems to have so well adapted itself to the particular conditions under which it lives that the hatching of the eggs seems in the vast majority of cases to be timed perfectly to the development of the gall. Of course the development of the insect and the development of the plant host are subject to many of the same influences, and both respond to these influences in a corresponding degree, otherwise the "plans" of the Chermes would miscarry.

PARTHENOGENESIS

No mention thus far has been made of the male Chermes abietis, because it is believed that none exists. Buckton believed at one time that he had found a specimen of the male sex, and described it minutely, but his observations have since been shown to be erroneous. Scientists have long searched in vain for the male of this species, and it is now thought to be entirely parthenogenetic.

MEANS OF DISSEMINATION

It has been elsewhere noted that the powers of flight of this species seem to be rather poor, and it seems quite unlikely that it will spread to any great distance by means of its own flight, or even by the wind. The pest has, however, been widely disseminated upon nursery stock. Infested nurseries are likely to serve as distributing centres for this pest, and the danger is greater because of the fact that during the shipping season the insects are in the hibernating condition and are hardly visible to the naked and untrained eye. This danger can be avoided by buying trees from nurseries where the pest does not occur, or by thoroughly spraying the trees with the proper materials when they are first received from the nursery.

NATURAL ENEMIES

All species of Chermes seem to be comparatively free from the attacks of parasitic insects. A few species of Chalcids have been reported as parasitic upon species of Chermes, but Cholodkovsky states that with all his work upon this group he has seen but one undoubted case of parasitism in all the species studied.

This insect is, however, attacked by a number of predaceous enemies. Cooley records finding the larvae of Chrysopa oculata

Say feeding on the nymphs as they emerged from the galls. Small spiders have been observed building their webs over the galls, thus catching the last stage nymphs and winged adults as they appeared. The larvae of Syrphids have been reported feeding on some species of Chermes in their galls, but probably are unable to enter the closed galls of this species.

CONTROL

General Considerations

The old saying, "an ounce of prevention is worth a pound of cure" applies to this as well as all other insect troubles. In buying spruces for ornamental or other planting, it is well to make sure that Chermes abietis L. is not present. If not brought in with the trees when set, the chances are very much against the appearance of this pest.

When once established, control measures must be resorted to. There seem to be two possibilities: either remove the galls when the insects are present in them, or spray at some time when the insect is in an exposed situation and a susceptible condition, which, recalling the life history of this species, is the case in the late fall, winter, and early spring.

Hand Picking

When only a few small ornamental trees are to be protected, the best method is probably to cut off the galls and burn them while the Chermes are enclosed within them, which in the vicinity of Amherst means late in June, in July, or in the early part of August. It is, of course, useless to cut off the galls after the insects have left them, although this is frequently done by nurserymen when shipping spruces in the winter or spring, which may explain the appearance of the pest on trees which were apparently clean when set out. When cutting off the galls, it seems best to burn them, because if nearly mature, they may dry out, open, and liberate the nymphs, which may transform to winged adults and reach a spruce tree if any be near.

SPRAYING

If the spruce gall louse is very abundant, especially on large trees, spraying will be necessary. The time to spray is of course when the insect is exposed and susceptible to the action of spray materials. Spraying is useless in the summer, when the insects are securely enclosed within the gall. As the galls open, the nymphs emerge, molt, and transform to winged adults, which lay eggs almost immediately. Since all the adults do not appear at the same time, there seems to be no favorable opportunity for spraying until after all the eggs hatch, which,

as has already been stated, may not be until after the middle of November. The insect remains exposed after hatching in the fall until the eggs are laid in the spring, and while spring is usually recommended as the best time to spray for this species, it can be successfully controlled at any time during the late fall or winter, when weather conditions permit.

Preliminary Experiments

Method of procedure. Before conducting spraying experiments on a large scale it seemed advisable to test a number of spray materials in a small way in the laboratory. In trying out the various spray materials, fresh twigs thoroughly infested with the gall louse were brought in and sprayed with the material on trial. The twigs were then placed in moist sand to keep fresh, and examined two or three days later to determine the efficiency of the spray. In scoring the results it was impossible to get an exact count of the number alive before and after spraying. The young insects are so completely covered with woolly secretion that the only way of determining whether or not an individual is alive is to turn it over with the point of a needle and observe the movements of the antennae and legs, which at best are very sluggish. If subjected to this treatment before spraying, the insect may die from the breaking of its fine delicate setae, or other injury, rather than from the effects of the solution applied. It is therefore impossible to obtain an accurate count of the number of insects killed by the spray, and for that reason the relative numbers alive after spraying are

classified as "none", "very few", "few", and "many." In making the examinations, it was found best to let the twigs stand two or three days before looking them over, when the dead individuals would be dried up, while those uninjured would be plump and full, and on removal with a needle and close examination, would show movement of the legs and antennae.

Preliminary Experiments in the Fall of 1916.

Whale-oil soap. This has been the standard remedy for the spruce gall louse, and has been recommended for use at the strength of one pound in two gallons of water. In these experiments a commercial preparation has been used which was said to contain tobacco, and also a soap without tobacco.

Experiment Nov. 8. Whale-oil soap "with tobacco"

Dilution	Results
20 lbs. per 100 gal.	none alive
10	" "
6 2/3	" "
5	many "
4	" "
2	" "
check	" "

Experiment Nov. 18 Whale-oil soap "without tobacco"

Dilution	Results
15 lbs. per 100 gal.	none alive
13	" "
11	" "
9	" "
7	" "
5	many "
check	" "

Experiment Dec. 1. Whale-oil soap with and without tobacco.

Dilution	Results	
	With tobacco	Without tobacco
8 lbs. per 100 gall.	none alive	none alive
7	" "	" "
6	" "	" "
5	" "	" "
check	many "	many "

In the experiments tabulated above it will be seen that whale-oil soap was effective in all cases at the rate of seven pounds per hundred gallons, and in several cases a greater dilution killed all the insects. The preparation containing tobacco failed to show any greater effectiveness than that without it.

Kerosene Emulsion

This standard remedy for plant lice in general was reported by Cooley to be ineffective against the spruce gall louse, no reason being assigned for its failure to give results. The following experiments were tried in the fall of 1916.

Experiment Nov. 15. Kerosene emulsion.

Dilution		Results
Stock 1 - water	5	none alive
	7	" "
	9	" "
	12	" "
	15	" "
check		many "

Experiment Nov. 18. Kerosene emulsion

Dilution		Results
Stock 1 - water	15	very few alive
	18	" " "
	21	" " "
	25	" "
	30	many "
check		" "

Experiment Dec. 2. Kerosene emulsion.

Dilution		Results
Stock 1 - water	9	none alive
	11	very few alive
	13	" "
	15	very " "
check		many "

From the experiments just noted, it will be seen that kerosene emulsions vary greatly in their effects on the spruce gall louse,

due possibly to variations in composition, or to variations in composition, or to variations in the conditions under which the work was carried on. In all cases, however, the usual dilution recommended for plant lice - 9 gallons of water to one of stock - was effective.

Miscible Oils.

Commercial miscible oils are used as contact sprays, and their use was suggested to the writer. Below are the results of experiments with this material:

Experiment Nov. 15 and Nov. 18 Miscible oil.

Dilution	Results
1 - 10	none alive
20	" "
30	" "
40	" "
50	" "
60	" "
70	" "
80	" "
90	few "
check	many "

A repetition of the same experiment on December 2nd gave identical results.

Nicotine Sulphate

At present this is the most widely used spray material for the control of plant lice. Soap is ordinarily added to give the solution penetrating power and adhesiveness, and was used in the first experiment.

Experiment Nov. 6. Nicotine Sulphate (with Ivory soap 4 lbs. per 100 gal.)

Dilution	Results
1 - 800	none alive
1 - 1000	" "
1 - 1200	" "
1 - 1400	" "
1 - 1600	" "
1 - 1800	" "
1 - 2000	" "
soap solution alone	" "
check	many "

This experiment indicated that a solution of high grade soap 4 lbs. per 100 gallons was in itself an effective insecticide in this instance, which led to later experiments with soaps.

The next experiment was for the purpose of ascertaining the effectiveness of the tobacco extract with various strengths of soap solutions. Ivory soap was taken as being fairly representative of the high grade soaps, and was easy to obtain.

Experiment Nov. 13. Nicotine sulphate with different strengths of Ivory soap solution.

Dilution	Results							
	no soap		1 lb.-100 gal.		2 lb. - 100 gal.		3 lb.-100 ga	
1 - 1000	many	alive	many	alive	many	alive	none	alive
1 - 1500	"	"	"	"	"	"	-	-
1 - 2000	"	"	"	"	"	"		
check	"	"						

The next experiment was to determine the exact strength of nicotine sulphate necessary to kill the insects, comparing it with the amount necessary with a soap solution.

Experiment Nov. 13. Nicotine sulphate (with and without Ivory soap 3 lbs. per 100 gallons.)

Dilution	Results	
	Without soap	with soap
1 - 200	none alive	-
1 - 400	" "	none alive
1 - 600	few "	-
1 - 800	none "	none alive
1 - 1000	many "	" "
1 - 1500	- -	" "
1 - 2000	- -	" "
check	many alive	

The results of experiments as noted above indicate that without soap nicotine sulphate is not very effective unless used at greater strengths than the usual recommendations. On the other hand, if soap is used, the nicotine sulphate seems to add very little to the effectiveness of the mixture.

Soap.

Following out the possibilities previously indicated, common soap, was given a more extensive trial. "Ivory" soap was taken as being typical of a standard high grade soap, and "Lenox" soap for the cheaper laundry soap.

Experiments Nov. 7 and Dec. 1. Ivory soap

Dilution	Results
7 lbs. per 100 gal.	none alive
6	" "
5	" "
4	" "
3	" "
2	many "
1	" "
check	" "

Other experiments with Ivory soap gave identical results.

Experiment Nov. 15. Lenox Soap

Dilution	Results
15 lbs. per 100 gal.	none alive
12.5	" "
10	very few "
8	" " "
6	few "
4	many "
2	" "
check	" "

Experiments Nov. 18 and Dec. 1. Lenox Soap

Dilution	Results Nov. 18	Results Dec. 1.
14 lbs. per 100 gal.	none alive	- -
13	" "	none alive
12	" "	" "
11	" "	" "
10	" "	" "
9	- -	" "
check	many alive	many "

The above experiments indicate that Ivory soap is effective at the rate of three pounds per hundred gallons, while the laundry soap was not entirely effective until a dilution of more than ten pounds per hundred gallons was reached.

Preliminary Experiments in the Spring of 1917

The preliminary experiments conducted in the fall of 1916 were repeated the following spring before feeding had commenced. A detailed account of these experiments follows.

Experiment April 3. Whale-oil soap

Dilution	Results
10 lbs. per 100 gal.	None alive
9	" "
8	one individual alive; rest dead
7	none alive
6	" "
check	many "

With one doubtful exception, the insects were fully as susceptible as they were the preceding fall.

Kerosene Emulsion

An experiment with kerosene emulsion showed the insects to be apparently more susceptible to it than they were the preceding fall.

Experiment April 9. Kerosene emulsion

Dilution		Results	
~~Water~~ 1 - ~~stock~~	5	none	alive
Stock 1 — water	7	"	"
	9	"	"
	11	"	"
	13	"	"
	15	"	"
check		many	"

"Miscible Oils"

An experiment with one of the oils gave slightly less favorable results than those obtained the previous season.

Experiment April 5. Miscible oil.

Dilution	Results	
1 - 40	none	alive
50	"	"
60	"	"
70	many	"
80	"	"
90	"	"
check	"	"

Nicotine Sulphate

This was first tried without soap and found to be ineffective at all dilutions weaker than 1 - 200. With four pounds of laundry soap in 100 gallons of water, all strengths down to 1 - 2500 were apparently effective. The following table combines two experiments.

Experiments April 5 and April 9. Nicotine sulphate with Lenox Soap 4 lbs. per 100 gallons.

Dilution	Results
1 - 200	none alive
400	" "
600	" "
800	" "
1000	" "
1250	" "
1400	" "
1500	" "
1600	" "
1800	" "
2000	" "
2250	" "
2500	" "
soap solution alone	a few "
check	many "

Soaps

Experiments with Ivory soap on April 3rd., showed that it was effective as dilute as 4 lbs. per 100 gall., approximately the same result obtained the previous fall. Lenox soap gave the same results as previously, all dilutions down to 11 pounds per 100 gallons being totally effective.

After the insects had molted in the spring, but before egg laying had commenced, one experiment was tried, using whale-oil soap, to note any possible change in susceptibility to the spray material.

Experiment May 16 Whale oil soap. After molting and before egg laying

Dilution	Results
20 lbs. per 100 gal.	none alive
15	" "
10	" "
8	" "
6	" "
4	a few "
check	many "

It will thus be seen that for some time after molting and beginning their growth, the insects are fully as susceptible as when in the hibernating condition. After egg laying had commenced, one more spraying was made to find out whether the eggs could be killed by the spray, and whether the insects were becoming any more resistant.

Experiment May 24. (after egg-laying had commenced)

Whale oil soap.

Dilution	Results
10 lbs. per 100 gal.	none alive
8	a few "
6	" " "
4	many "
3	" "
check	" "

From this experiment it is evident that after egg laying has commenced the Chermes are somewhat less susceptible to the spray material. In all cases the eggs which were sprayed hatched in due course of time as well as those unsprayed.

Conclusions from laboratory experiments

The strengths of the various spray materials found necessary to kill the insects under laboratory conditions may be noted in the preceding detailed accounts.

The hibernating form seems to be about equally susceptible throughout the late fall and early spring, and the growing "stem mother" has about the same degree of susceptibility as the hibernating form, up to the time when egg-laying is about to commence.

The eggs cannot be killed by the same strengths of spray materials which will kill the other stages mentioned. Spraying should be completed some time before egg laying commences.

Field Spraying Experiments.

Fall of 1916.

Early snowstorms made it impossible to complete the experiments planned for the fall of 1916. While the results obtained are incomplete, they seem to be conclusive for the only materials tried, which were whale oil soap and laundry soap.

Since it was impracticable to use more than one dilution of each substance, it seemed best to use a strength somewhat in excess of that indicated by the preliminary tests as effective, in order to allow for possible differences in conditions. The trees sprayed were small ones, about three feet high. The results are tabulated below.

Tree no.	No. galls in 1916.	Spray material	Dilution	No. galls in 1917
1	7	whale oil soap	10 lbs. per 100 gal.	0
2	55	" " "	" " " " "	0
3	44	"Lenox" soap	15 " " " "	0
4	7	" "	" " " " "	0
5	26	check	- - - - -	20

Spring of 1917

The spraying experiments planned for the spring of 1917 were more completely carried out and more satisfactory than those conducted in the previous fall. In all cases the spray solution was made somewhat stronger than the preliminary experiments had indicated as necessary, in order to allow for

possible differences in conditions and to be sure of success in the limited amount of time at the disposal of the writer. The trees sprayed were scattered about the college campus, and were in all cases severely infested, making the results fairly conclusive. Below is a tabulation of the results.

Tree no.	No. galls in 1916.	Spray material	Dilution	No. gals. in 1917
1	(about) 350	"Ivory" soap	6 lbs. per 100 gal.	0
2	" 350	Whale-oil soap	10 " " "	1
3	450	Nicotine Sulphate (with laundry soap)	1-1500 (4 lbs.per 100 gal.)	2
4	87	"Miscible" oil	1-40	0
5	175	Kerosene emulsion	1-9	0
6	140	Check	---	(about) 175
7	225	"	---	" 325

From the results obtained it will be noted that all five spray materials used gave very satisfactory results at the strengths applied. The failure to get absolute control was doubtless due to a failure to hit the insects with the spray, rather than to inefficiency on the part of the solution used. It occasionally happens that one of them will be protected by a bit of leaf or other substance, and not get hit when the spray is applied.

Injury to the Trees

Only one case of injury was noted, this occurring with a young Norway spruce sprayed with "miscible" oil at the strength of 1 - 20. This tree was very severely injured and failed to recover. No injury was noted where the same material was used at half this strength, but since oils of all kinds

are likely to do damage to evergreens, the writer cannot recommend their use. The use of kerosene emulsion is probably also attended with some danger.

Neither nicotine sulphate nor any of the soaps used caused any injury.

Advantages and Disadvantages

Common soap. Where heat is readily available so that they can be easily dissolved, the ordinary soaps will be found as satisfactory as anything for the control of the spruce gall louse. Many of the soaps can be bought in the form of chips or flakes, making the mixing of the solutions a simple matter where hot or warm water can be readily obtained. In cold weather, however, the soap solutions become thick when cold, and are likely to cause trouble with the pumps unless sprayed out while still slightly warm. No definite figures can be given on prices, but at normal prices, ordinary soap will be found as cheap as anything that will do effective work. Taking into consideration the greater dilution at which it can be used, a high grade soap such as "Ivory" will be found cheaper than laundry soap.

Whale-oil soap. This should be known as fish-oil soap. While heat is necessary for the preparation of this soap, it is otherwise very easy to handle and does effective work, but is usually a little more expensive than common soap.

Nicotine sulphate. With laundry soap, 4 pounds per hundred gallons, nicotine sulphate solution as dilute as 1 - 1500, or about (= 1 - 800 one pint per hundred gallons,) is effective, and fairly cheap. At that dilution the soap solution will not thicken when cold.

"Miscible oil" and kerosene emulsion. On account of the danger of injury to the trees, it is not safe to recommend the use of these two materials.

Recommendations.

If possible, keep the spruce gall louse from becoming established in new plantings by using only clean nursery stock.

If a slight infestation is found, especially if the trees are small and can be easily covered, cut out and burn the fresh galls between the middle of June and the middle of August.

If the infestation is severe, or very extensive, spray between the middle of November and the first of May when the weather permits. Any of the following materials will be found effective.

1. Common soap. If laundry soap is used, dilute to 15 lbs. per 100 gallons. If a high grade soap, such as "Ivory" is used, dilute to 6 lbs.per 100 gallons. These can be

handled to best advantage when slightly warm.

2. Whale-oil soap solution, 10 lbs. per 100 gallons.

3. Nicotine sulphate, diluted 1 - 1500, with the addition of laundry soap, 4 lbs. per 100 gallons.

Whether cutting out the galls or spraying for the control of this pest, thoroughness is essential.

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The following bibliography, while quite incomplete, includes nearly all American accounts of the spruce gall louse, and all European works consulted by the writer in preparing this paper.

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Plates.

The following plates illustrate a few of the phases of the life history of the spruce gall louse.

I a. Hibernating young
b. Mouth parts of hibernating form.
c. Eggs laid by the winged female.
d. Eggs laid by the "stem mother" in the spring.

II a. Winged female
b. Antenna of hibernating form.
c. Antenna of winged female.

Plate I

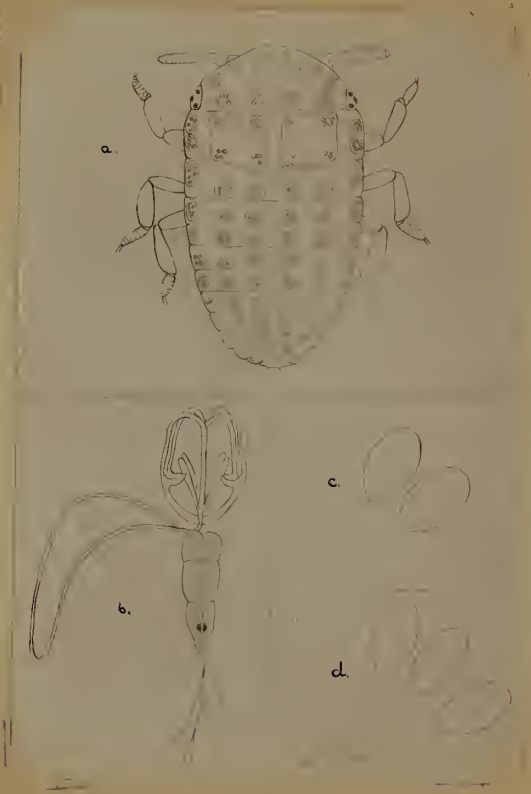
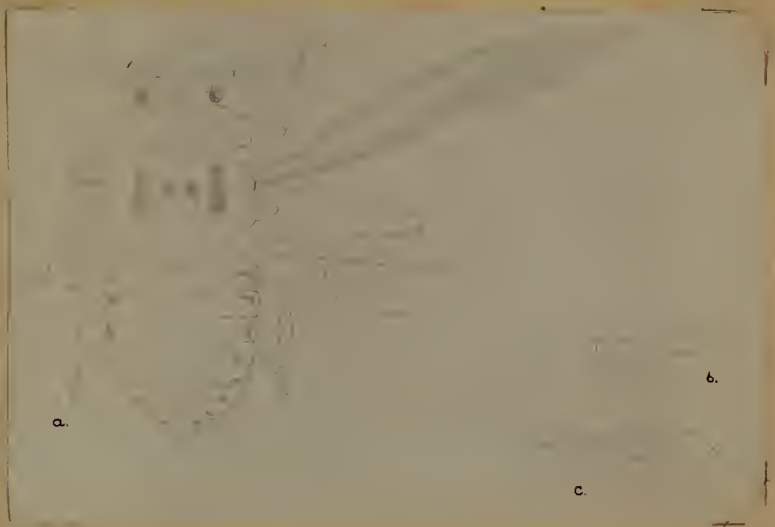


Plate II



The Host of Ablerus clisiocampae Ash. (Hym.).*

The following note is in corroboration of the observations made upon the host of *Ablerus clisiocampae* Ash. by L. T. Williams. (Psyche, October, 1916.)

In the spring of 1915, the writer bred several specimens of *Ablerus clisiocampae* from the eggs of *Malacosoma americana* Fab., but at the time was unable to make sure that the parasite had not emerged from a scale insect, although it hardly seemed possible. In the spring of 1916, after a few specimens of *Ablerus* had appeared, a number of egg masses were taken from the twigs, and thoroughly examined for the presence of scale insects, but none were present. With all possible chance of the presence of scale insects thus eliminated, the parasites continued to emerge from the egg masses in fair numbers. A repetition of the experiment gave the same result.

These observations corroborate those made by Williams and the original ones made by Ashmead, that this species, contrary to the habits of the family to which it belongs, does at least at times parasitize the eggs of a Lepidopterous insect.

In addition to *Ablerus clisiocampae*, three other species of parasites were bred from the egg masses. They were kindly determined for me by Mr. A. A. Girault as *Telenomus coloradensis* Crawford, *Tetrastichus malacosomae* Girault, and *Ooencyrtus* sp. Of these, *Tetrastichus malacosomae* was by far the most abundant, the other two species being only occasionally found.—B. A. Porter, Amherst, Massachusetts.

*Contribution from the Entomological Laboratory, Massachusetts Agricultural College.